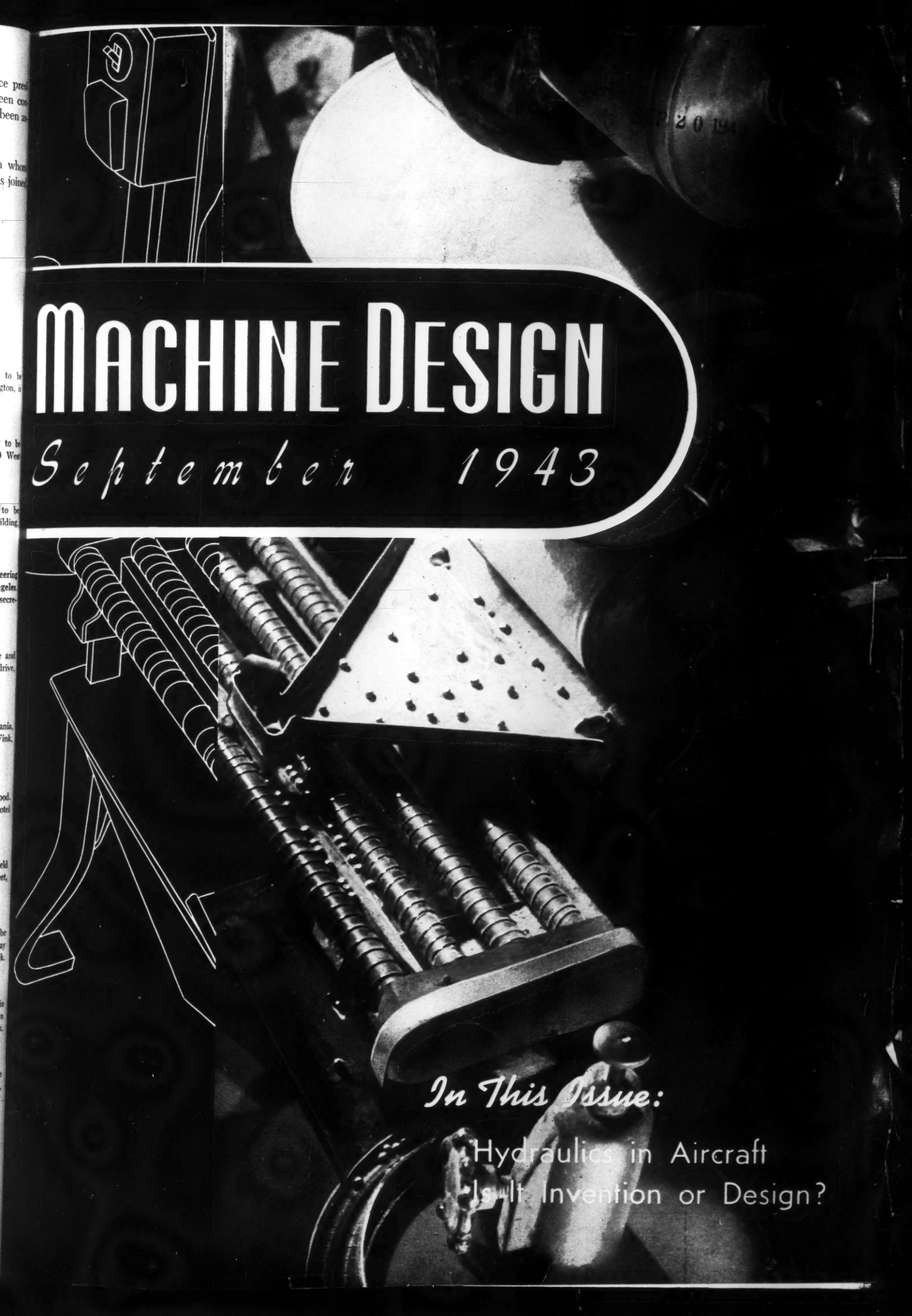

MACHINE DESIGN

September 1943

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Hydraulics in Aircraft

Is It Invention or Design?

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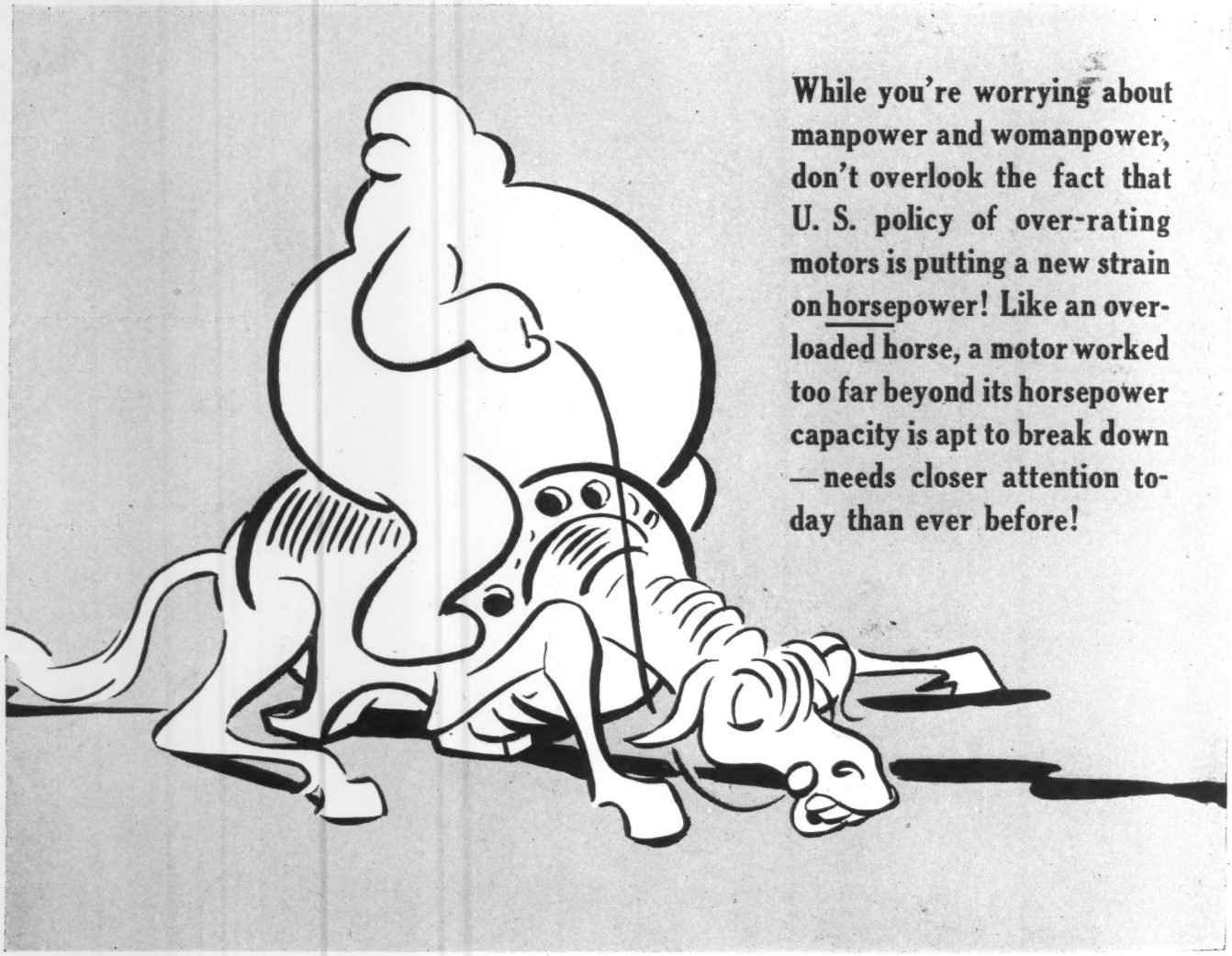

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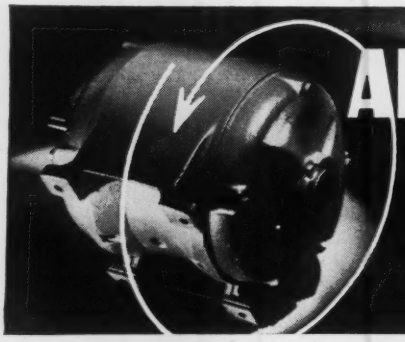

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MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 15 SEPTEMBER, 1943 Number 9

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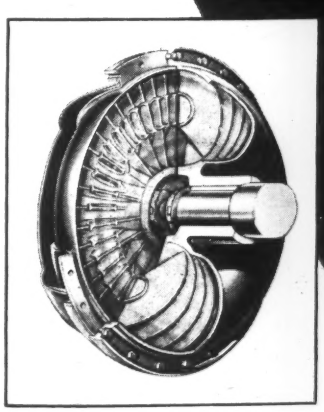


Cutaway view of American Blower Fluid Drive. There is no mechanical connection between driving and driven members.

Topics

GYRO - STABILIZERS increase the shooting accuracy of the new army tanks, enabling the gunners to fire with precision even while racing at full speed over the shattered terrain of a battlefield. Despite the pitch of the tank the stabilizer keeps the gun barrel at a fixed elevation and the target within focus of the gunner's telescopic sight. By this means, high-velocity 75-mm guns are able to outperform the best that the Germans have to offer.

LIGHTWEIGHT PLASTIC aircraft flooring installed on the after-deck of the Martin Mars is laminated-phenolic sheet reinforced with aluminum alloy strips. Weighing approximately ¼-pound per square foot less than other types of flooring of equal strength and carrying capacity, the material represents a saving of 423 pounds on a 50-ton flying boat. Using the estimate that a single pound of weight is worth $500, a saving of $211,500 is realized from this item alone!

BONDING solid sheets of synthetic rubber to welded steel, wood or concrete extends the application of this material into fields rubber alone cannot handle.

ONE-MILLIONTH-SECOND exposures for photographs, fast enough to "stop" a rifle bullet, can be made with a high-speed electronic light unit, comprising a mercury lamp, an electronic tube and a capacitor. The tube rectifies the current and charges the capacitor. This flashes the light at 2000 volts and 2000 amperes. Although the lamp has a useful life of but one second it is good for 1,000,000 exposures.

PROBLEM OF KNOWING when additional oxygen is needed by high-altitude fliers may be solved by the use of phototubes. A tiny light and midget tube are supported on opposite sides of the ear lobe by a spring clip. As the color of the blood changes with the oxygen content, the output of the tube changes accordingly.

WITH ALUMINUM production sufficient to meet requirements for the all-metal types of planes, the War department has canceled contracts for manufacture of wood cargo airplanes designated as C-76. This plane was designed as a medium range plane with a cargo capacity of about 4,500 pounds, constructed mostly of wood and to a considerable extent by subcontractors not fully engaged in war work. An actual shortage of the kinds of wood best adapted to plane construction has developed. Also, flights with the experimental model have established that the plane would be more expensive and less efficient than those now being manufactured from metal.

METAL PLATING of plastics extends the application of this versatile material to many fields. It provides protection against attack from various solutions; oils, solvents and moisture cannot be absorbed; heat resistance is increased; magnetic and electric shielding are obtained; metal parts may be matched by the plated plastic, utilizing simple molding techniques.

PROGRESS in synthetic rubber production is indicated by growth in plants for producing raw materials. Only 3 per cent of requirements a year ago, the capacity rose to 15 per cent at the beginning of the year and by the end of June became 61 per cent.

MORE THAN 1000 war engineering research projects have been completed by a task force of automotive engineers as part of the continuing war engineering program of the Society of Automotive Engineers.

MAGNETIZED STANDARDS for optical systems employ alnico to facilitate adjustments in delicate systems, obviating tedious clamping. With metal tables or vertical surfaces, the units stick where placed, thus avoiding trouble from the tightening of clamps.

MORE THAN 11,000,000 horsepower of steam turbine propulsion equipment will be produced by General Electric this year for Navy and Maritime Commission ships. This is eight and one-third times the production of 1941. In 1944 production will be ten times as high.

MACHINE DESIGN

Aircraft Experience Aids Industrial HYDRAULICS

By Lieut. Commander Harry J. Marx, U.S.N.R.*

Bureau of Aeronautics, Navy Dep't.

IN TIMES of emergency, American industry has always demonstrated its ability to join hands in a united and cooperative effort to solve the problems that confront the nation. Our production of war goods has been enormously expanded as a result of such unified effort. This has required a thorough investigation of the other man's problems and a complete evaluation of

*Opinions or statements contained in this article are those of the author and should not be construed as reflecting the official views of the Bureau of Aeronautics.—Ed.

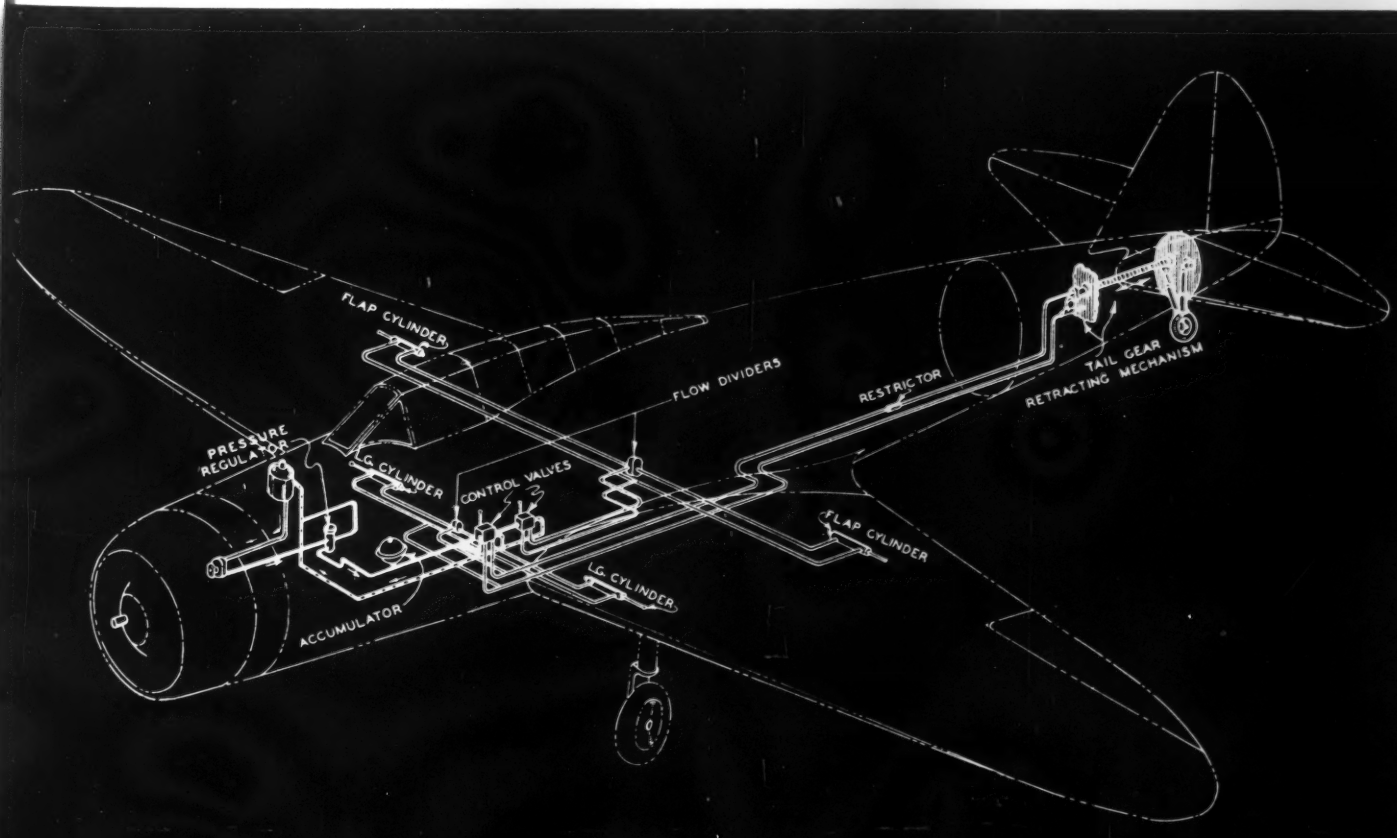
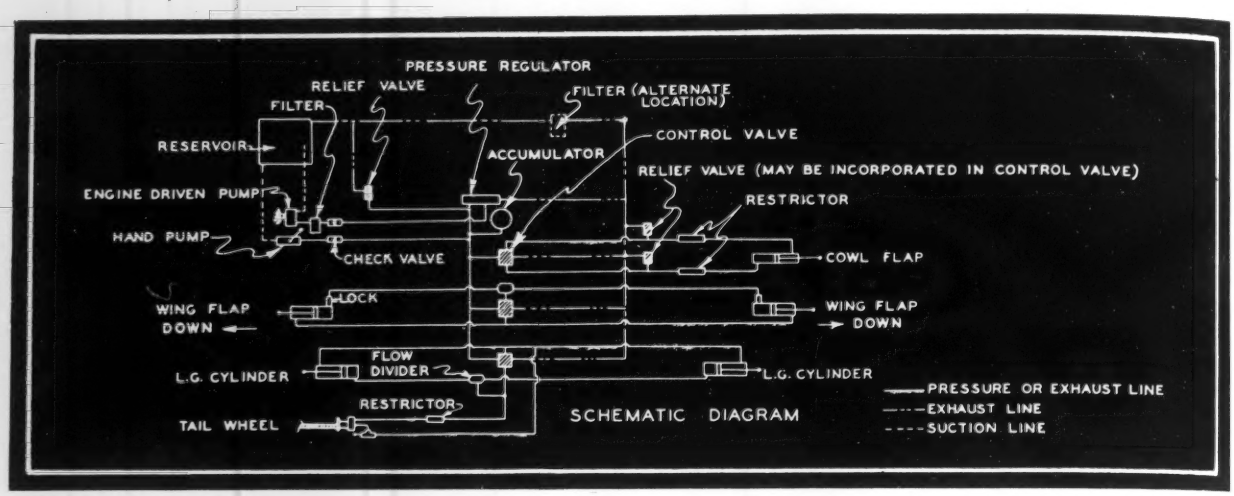


Fig. 1—Typical hydraulic installation on single-engine aircraft provides for control and operation of landing gear and landing flaps



—*Diagrams courtesy Pump Engineering Service Corp.*

Fig. 2—Above—Schematic layout of the installation in Fig. 1 shows how the essential units are interconnected

Fig. 3—Below—Aircraft pump, left, weighs 5.65 pounds while industrial pump, right, weighs 15.4 pounds. Capacities are approximately equal although former operates at 3750 revolutions per minute and 1500 pounds per square inch while speed of latter is 1140 revolutions per minute and discharge pressure is 500 pounds per square inch at rated speed

—*Photo courtesy Pump Engineering Service Corp.*

the essential differences that are encountered. New methods must be analyzed and incorporated in the production plan—methods which differ materially for the different types of equipment manufactured. In these articles, it is proposed to study the essential differences in design, application and production of hydraulic equipment for aircraft as compared to industrial uses.

In analyzing engineering or design requirements, it is first necessary to present the major or basic engineering differences such as size, weight, strength, costs, quality, finish and special problems. The next step is to consider the hydraulic fluids, and from then on it follows that the units of the hydraulic systems should be discussed.

Basic Engineering Differences

In any hydraulic circuit such as typified by *Fig. 2* there are three principal units of equipment, excluding the oil reservoir. These are the pump which converts mechanical energy into fluid energy; the control valve which controls the distribution of the energy; and the actuating cylinders or hydraulic motors which convert the fluid energy back into mechanical energy. This is basic and applies equally to aircraft and industrial hydraulics, the principles being the same for both.

Industrial hydraulic applications generally operate under favorable conditions. The surrounding temperature is usually 60 to 95 degrees Fahr. Oil temperature is approximately 80 to 120 degrees and where any serious temperature rise is anticipated, facilities for cooling are easily provided. Aircraft hydraulic equipment is subject to extreme differences in temperature range, from minus 70 to plus 160 degrees Fahr.

Maintenance Personnel Factors

Industrial hydraulic equipment is, in general, part of expensive machine equipment and is therefore under the normal supervision of experienced mechanics and maintenance personnel. Aircraft in combat service are compelled to operate under conditions that permit neither the time nor the conditions and facilities for proper maintenance. In combat operation any damage that is incurred must be repaired quickly and as efficiently as the supplies on hand and the available facilities permit. Snow, rain, hail, sand, dust, dirt, corrosion, intense heat and cold, vibration, etc., all are handicaps that are encountered and must be overcome in order to maintain continuous successful operation.

Weight has caused little concern in the field of industrial hydraulics and in previous years appearance has meant little. However, due to increased competition and also the greater demand for industrial hydraulic equipment, units have been and are now being designed to make a good appearance as well as to decrease weight. The latter results in reduction in material, labor, handling and shipping costs. Nevertheless the weights and sizes of industrial equipment far exceed the permissible limits for use in the aircraft field, *Fig. 3*. It must be realized that acceptable aircraft design is based on the maximum possible efficiency incorporated with the greatest possible reduction in size and weight. Safety factors are provided to eliminate hazard, but those so-called ignorance factors to cover unforeseen conditions are reduced to a minimum or eliminated. Physical characteristics of the materials are carefully analyzed and rigid inspection is required in order to assure absolute reliability and to make certain the physical characteristics are not reduced

due to variations in the material or the fabrication technique. For these reasons factors of safety can be more accurately relied on in final performance.

Use of aluminum alloys and the various alloy steels, in spite of higher material and production costs, has resulted in the maximum possible reduction in weight and size of aircraft equipment. In fact this reduction has been carried out to such an extent that the usual reaction, as expressed by the industrial engineer, is one of extreme doubt of the strength of the units. Unquestionably experience gained in the aircraft field will have a decided effect on industrial hydraulic designs in postwar periods.

Relative Costs

Industrial hydraulics require a margin of safety which at times may waste power but will in the final analysis save money and time as a result of ease of production and a lower maintenance cost. Industrial equipment is therefore less expensive. Further, the employment of established standards and units which can be used for many different applications results in equipment at still lower cost. The rigidity of material and production inspection tests of aircraft hydraulic equipment combined with the use of the higher-priced special alloys and the increased production costs has inevitably raised the prices of aircraft equipment to values that at first seem extraordinarily high. In fact high prices have tempted many a firm to accept orders at quotations that seemed fabulous —then, to their dismay, rejections and production problems have made their profit and loss statements appear decidedly discouraging. Moreover, the diminishing supply of skilled workmen has made compulsory the use of specialized machines designed to be as foolproof as possible, for operation by unskilled labor or hastily trained women.

Quality and finish can easily be misunderstood and incorrectly interpreted. The ordinary hydraulic jacks sold in automobile supply houses are an application of industrial hydraulics. They are made for a highly competitive and price-conscious market. Neither quality nor finish need be considered essential. A step further along is the average small hydraulic press used in the service garage and in many small shops and factories. Such presses are used for straightening bars, shafts, angles, and frames, to press in bearings and bushings, and for a multitude of similar operations. Price is usually the major consideration and efficiency is apt to be entirely secondary. Finish is entirely a question of the initial appearance.

As the industrial application becomes more advanced, efficiency, and therefore the quality, of the unit becomes more important. Precision machining becomes more essential and in many cases equals the demands of the aircraft field. Finish, in general, is more a question of protection, appearance and utility. A corrosion-protective coating that is durable will serve in the majority of industrial applications with the possible exception of such cases where contact with or proximity to corrosive liquids and similar materials may require special treatment.

For aircraft applications, use of aluminum and in some cases of magnesium alloys makes anodizing and similar protective treatments necessary. Protective chromate paints and enamel coats usually are applied. Steel surfaces are cadmium, chromium or, due to shortages of critical materials, even zinc plated. Due to the minimum wall thicknesses that are employed, the outside surfaces are usually machine finished so that tolerances can be maintained and surface blemishes of unknown depth can be eliminated. All this requires quality standards throughout the entire fabrication process and necessitates considerably greater attention to proper finishes in conformance with specification requirements.

Problems in Aircraft Hydraulics

Special problems encountered in both fields are numerous and it is the purpose of this article to place greater emphasis on those of the aircraft field inasmuch as industrial applications are as yet unlimited and each new application will present new problems for solution. As an example of these special problems in the aircraft field, attention is called to the temperature differential of 230 degrees Fahr. which is encountered. Any unit which is an assembly of parts of different metals or materials must

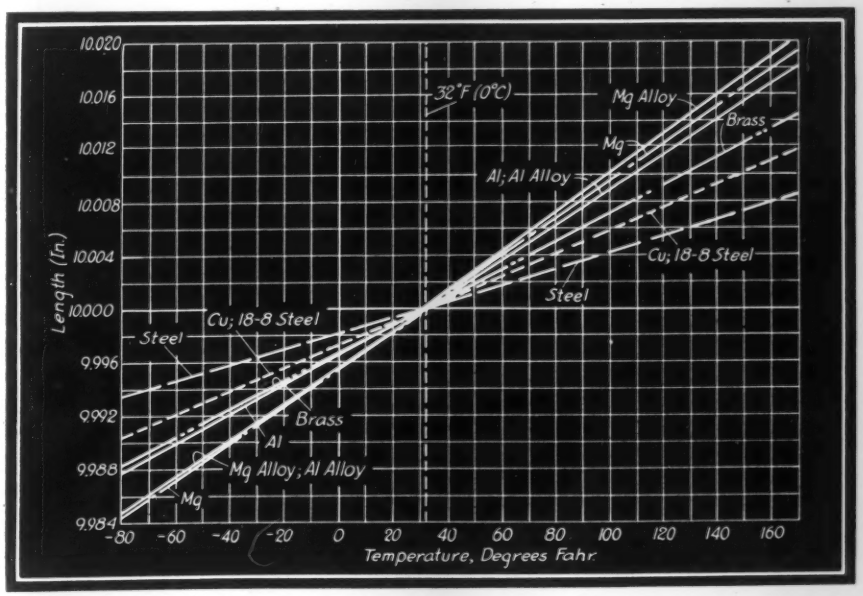


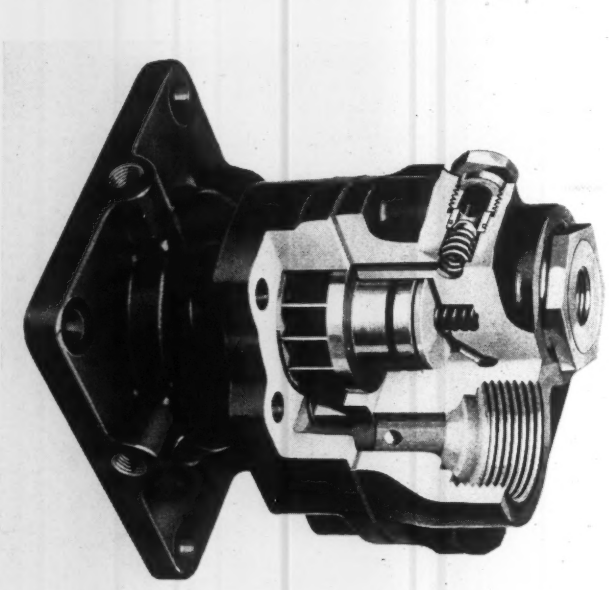
Fig. 4—Chart shows effect of temperature changes on relative dimensions of parts made from different engineering materials

be studied in order to determine the effects of the various coefficients of expansion, *Fig.* 4. Operation pressures from 1000 to 3000 pounds per square inch, and hydraulic fluid of low viscosity values create leakage problems. Also, where moving parts are involved, *Fig.* 5, the respective expansion and contraction may result in seizure or the opposite extreme of by-passing or leakage of fluid. Close tolerances are essential but they must also be closely analyzed for the effect of expansion and contraction.

Hydraulic Fluids

Manufacturers of industrial hydraulic equipment have not encountered the range of problems related to oil characteristics that are typical of the aircraft field. Of course, hydraulic fluids for industrial application have their own particular requirements but, as was stated above, the wide range of temperature variation encountered in combat aircraft operation may be considered as being the source of the majority of aircraft problems.

Viscosity: One of the most important characteristics of any hydraulic fluid is the change in viscosity over the operating temperature range, *Fig.* 6. A temperature variation of 60 to 110 degrees Fahr. is not great in comparison to the change from minus 65 to plus 160 degrees Fahr. For example, the commonly used hydraulic fluid conforming to Navy specification M-339 has a viscosity of 240 saybolt seconds universal at 60 degrees Fahr. and at 110 degrees about 80 saybolt seconds universal. But in the aircraft range of minus 65 degrees Fahr., viscosity measurements run into millions, in fact, the pour point of the fluid has been passed. Then again, at 160 degrees viscosity has gone down to 49 saybolt seconds universal. As a result of requirements for operating at low temperatures beyond the pour point of this oil, it has become necessary to develop a new fluid. This has viscosities of 74 saybolt seconds universal at 100 degrees Fahr. and approximately 1,800 saybolt seconds universal at minus 65 degrees Fahr. In the field of industrial hydraulics few manufacturers have encountered such viscosity values.



—*Photo courtesy Pump Engineering Service Corp.*

Fig. 5—Pump clearances are affected by temperature changes if dissimilar metals are employed for stationary and moving parts as in this aircraft pump

For any hydraulic equipment there exists an optimum viscosity at which the maximum overall efficiency will be attained. Any reduction in viscosity will result in leakage and loss of volumetric efficiency of the pumping unit and therefore a lower overall mechanical efficiency of the complete system.

Oils used for industrial equipment usually have a viscosity of approximately 150 saybolt seconds universal at 100 degrees Fahr. Where high temperatures are anticipated, viscosities varying from 200 to 1,000 are frequently employed. Where low temperatures are anticipated, particularly in equipment used outdoors, oils having a viscosity as low as 50 saybolt seconds universal have been used.

Viscosity Index: Viscosity index indicates the ability of an oil to resist changes in viscosity due to changes in temperature. As already indicated, all mineral oils have the characteristic of thinning down when subjected to heat, and thickening when chilled. Some oils, however, change their viscosity less rapidly than others. Those oils with the least viscosity variation over the temperature range have a higher viscosity index. The higher the viscosity index of the fluid employed, the better will be the mechanical efficiency of the hydraulic system, particularly where a wide operating temperature range is necessary.

Water Absorption and Foaming

Demulsibility: Demulsibility is the resistance of an oil to absorption of water. It is a known fact that hydraulic fluids will absorb some water, and the absorption of an excessive amount will result in a tendency of the fluid to foam as well as causing a corrosive action on the units of equipment. This foaming results in a decrease in film strength and therefore in the lubricating properties of the oil. Foaming is accompanied by air bubbles, which interfere with delicate control. Due to the high compressibility of air, this results in erratic piston and valve action and other undesirable operating features, as well as the possibility of binding of bearing surfaces because of the reduced lubrication value. In aircraft hydraulics all line sizes are reduced to a minimum, and where restrictions to flow are high this foaming tendency becomes critical; hence the demulsibility of the oil must be given careful consideration.

Low Temperature Characteristics

Pour Point: The temperature at which a fluid solidifies and can no longer be poured is an important consideration, particularly when the system operates at low temperatures. At high altitudes or in cold climates considerable difficulty may be encountered due to cavitation which is the result of excessive pressure drop or suction in the line from the reservoir to the inlet port of the pump. This should not be confused with viscosity index inasmuch as fluid with a low viscosity index may also have a low pour point. Therefore, a low pour point plus a high viscosity index is essential where wide ranges of the temperatures are encountered.

Stability: Stability is the characteristic of an oil

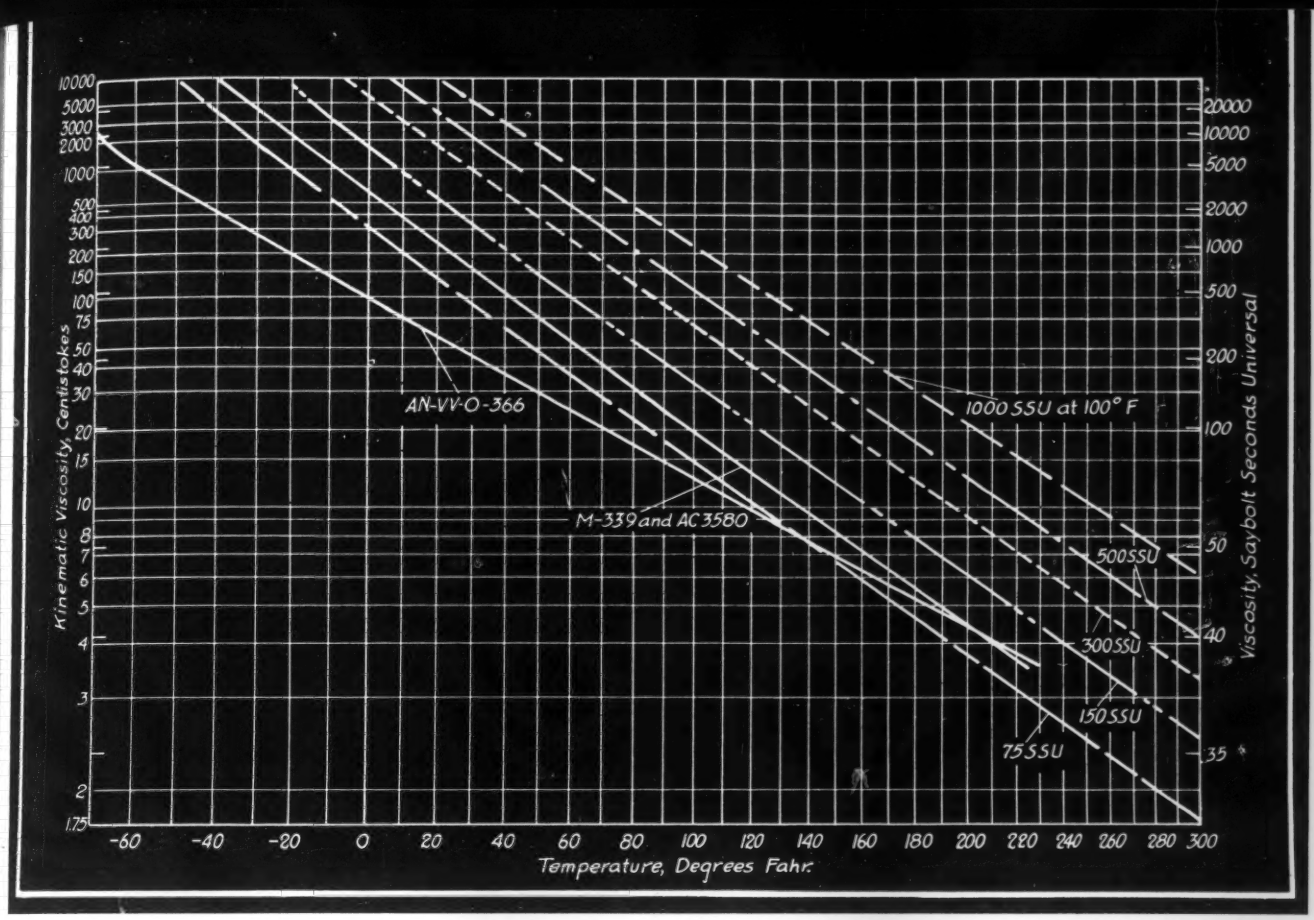


Fig. 6—Chart shows changes in viscosity of hydraulic fluids with temperature. Noteworthy is the high viscosity index of the new fluid AN-VV-O-366

which enables it to resist oxidation and deterioration. Although high temperatures are the most detrimental to the stability of hydraulic fluids and aircraft systems are more apt to encounter low temperatures, aircraft requirements necessitate some compromise in order to obtain other characteristics of the fluid. High operating pressures likewise have a deleterious effect on the stability characteristics of the oil. Fortunately, it may be added, any oil with a high viscosity index usually has good stability.

NEUTRALIZATION NUMBER: The neutralization number refers to the acidity of the oil and should be as low as possible to insure against corrosion and pitting of finely finished surfaces and bearings. In addition to the corrosive action on bearings, another similar characteristic that must be considered of major importance in aircraft equipment is the effect of the fluid on synthetic rubber seals and packings. Some oils have an excessive swelling action on these packings which results in binding and friction in parts like actuating cylinders, etc. For these reasons, the neutralization number for aircraft hydraulic fluids must not exceed .20.

FLASH AND FIRE POINTS: Flash and fire point requirements are important in determining the degree of refinement used in production. Operating temperatures in aircraft hydraulic systems are such that they do not approach either of these points. However, the element of fire hazard can never be neglected in aircraft equipment, and the possibility of incendiary bullets striking any of the hydraulic equipment must be considered. Fluid released at high pressure will readily form an explosive vapor in mixing with surrounding air and may be ignited by an incendiary bullet.

In summing up the characteristic requirements of hydraulic fluids, it must be pointed out that few types of industrial equipment justify and require more careful consideration than does the aircraft hydraulic system.

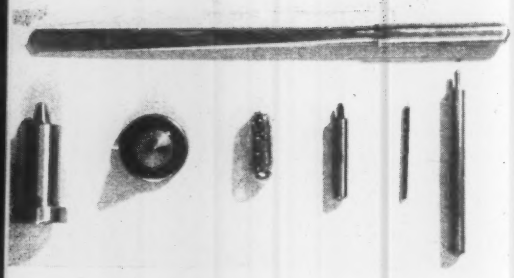
(Editor's note: In a subsequent article Commander Marx will discuss hydraulic pumps, control valves and actuating cylinders.)

Stratotrainer "Climbs" Faster Than Plane

KNOWN as the Stratotrainer, a new low-pressure chamber reproduces an atmosphere equivalent to that at an altitude far beyond 50,000 feet. It will be used exclusively for physiological research and the training of high-altitude crews by the Boeing Aircraft Co. The chamber can reproduce an altitude of 35,000 feet in two and one-half minutes and 50,000 feet in four minutes. The rate of climb will enable a study to be made of the factors which contribute to aeroembolism, which is the high-altitude equivalent of the deep-sea diver's bends. It will permit an exhaustive study of the present ceiling of man, raising it above the present peak of approximately 40,000 feet.

Size of the Stratotrainer, which consists of a metal cylinder equipped with motor-driven air pumps, permits the training of a complete flight crew at one time. An oxygen system is furnished which includes both the demand type and the constant-flow type. A large refrigeration unit on top of the machine keeps the temperature inside the chamber similar to that encountered within a plane at high altitude. Windows through which exterior observers may watch the test are provided with three layers of glass to prevent fogging through condensation.

Scanning the field for IDEAS

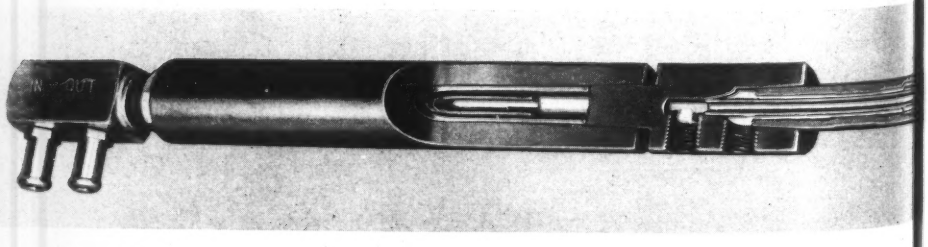


NEW horizons are promised through the commercial production of microscopic holes in practically any material with tiny precision drills. These drills, in sizes down to .003-inch diameter, have been used in drilling holes in diesel-engine fuel jets to provide increased horsepower and fuel economy as compared with previous types. So important is this that predictions are being made that it will lead to increased adoption of the diesel engine for trucks and passenger cars after the war ends.

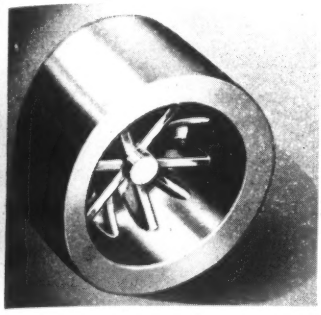
Other applications include a new nozzle for commercial oil burners which has only two parts, including a strainer compared with five for standard nozzles now in use. Oil is injected through five .006-inch holes. Experiments under way also indicate that television transmission over much greater distances will be possible with simplified apparatus employing a revolving disk with microscopic precision holes.

In the illustration, left above, are shown, left to right, two diesel-engine fuel jets, several hundred bearing sleeves (in a capsule) measuring .025-inch in length and .035-inch in diameter, a counterbore, a .0059-inch flat fish-tail drill, and a counterbore radius drill. The bearing sleeves shown are for precision instruments and are chamfered on both ends. Inside diameter is checked with .014-inch "go" and .015-inch "no-go" gages under a microscope at left and is concentric with the outside within .001-inch.

Replacement parts so designed that minimum expense and time are involved in renewal is consistent with a well-planned program. The welding electrode illustrated at right is typical of the economies possible



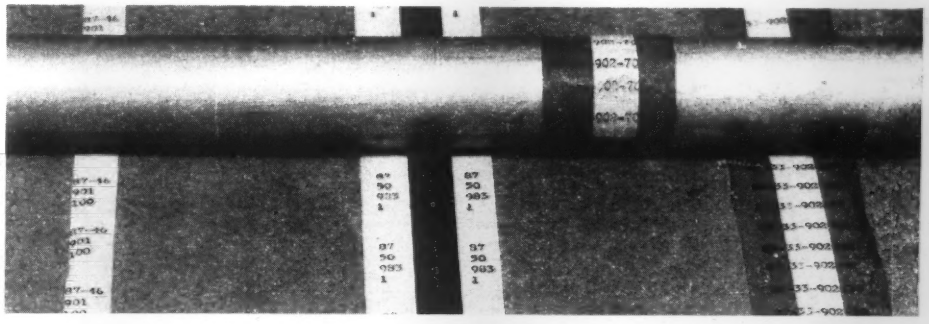
when such service factors are considered. Fitted into a conventional holder for resistance welding, the electrode is refrigerated and has a removable tip or cap with



a solder seal. None of the connections for refrigerant are disturbed when renewing the tip. Designed by Frostrode Products, the renewable tip, above, conserves considerable copper and is quickly replaced through the use of electrical pliers which melt the solder seal upon application.

Identification of tubing through color coding and part numbers is expedited by Curtiss-Wright Corp. through the use of a standard office addressing machine, below, effecting a saving of approximately 76 per cent over previous methods. The coded paper, in rolled strip form, is printed with the aid of a "galley-proofing" attachment as shown. Because of the width of an addressing plate, the paper is printed with three code numbers for each impression.

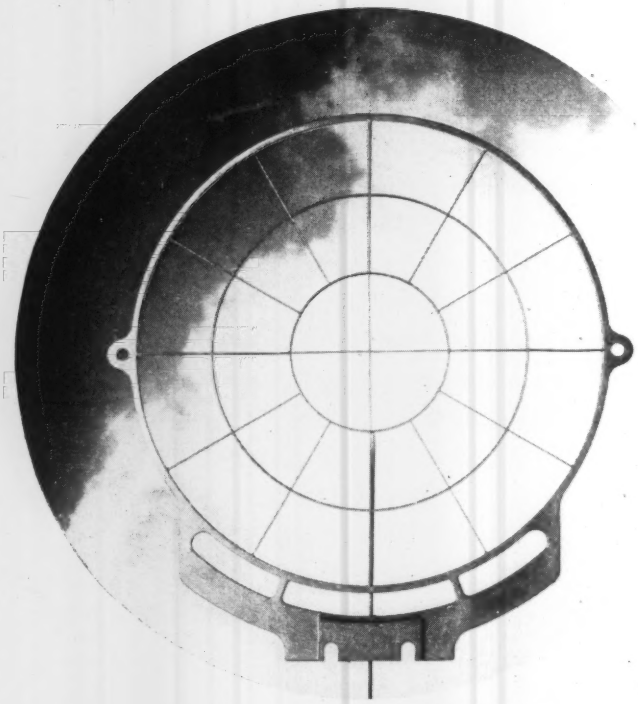
This coding permanently identifies each length of tubing, the paper being gummed for quick attachment. As an example: A tube banded with red indicates a gasoline line, a yellow band means lubricating oil, while a combination of yellow and blue stripes shows tubing for hydraulic fluid.



Stress analysis by a simpler and more direct method than obtainable through photoelasticity involves coating of an actual part or a model with a brittle lacquer. When stressed under operating or simulated operating conditions the lacquer cracks, leaving hairline patterns typical of stress distribution. Called Stresscoat, these lacquer "footprints" are readily analyzed. In the illustration at left is shown a gear tooth model being sprayed for such a study at the Westinghouse research laboratories. When squeezed in a 400,000-pound press the cracks betray the vulnerable points of differentially designed gears and tell how great a load can be put on gears for submarines and subchasers.

Die Castings in W

By D. L. Colwell*
Deputy Chief, Materials Branch
Conservation Division, War Production Board



—Photo, courtesy New Jersey Zinc Co.

Gun sight is one-piece zinc die casting. Measuring 11¼ inches in diameter the casting's cross ribs range from .035 to .05-inch in thickness, illustrating extreme thinness of sections possible

MUCH of the success in the production of military materiel in large volume has been due to typical American ingenuity and utilization of high production methods. One of these is the process of die casting. In past years die castings have been produced in volume by manufacturers of automotive parts, radios, washing machines, vacuum cleaners and business machines. Military items, however, because of their limited peacetime volume could not utilize the advantages of high-speed mass production methods.

With the current necessity for maximum production of parts with methods involving minimum labor costs, the die-casting process is coming into its own as depicted in the accompanying illustrations. Capacity once used to turn out hundreds of thousands of automotive parts, telephone parts, etc., now is available for production of fuse parts, aircraft parts, radio and radar parts, and other military items that run into large quantities. Many additional items undoubtedly will be die cast as soon as experimental work can be completed and supplies of raw materials assured.

Increase in aircraft production has been one of the most striking examples of change from slow, "custom-built" methods of production to the high-speed, straight-line methods used in the mass production of other items. This industry has begun to take advantage of the economies in time and labor offered by the die-casting process and, with the increasing certainty of the large quantity and high quality offered by the die-casting manufacturer, further increases are to be expected.

An outstanding example of the successful use of die castings in aircraft has been the construction of automatic flying controls redesigned for die casting by Jack & Heintz Inc. By the substitution of magnesium and aluminum die castings for other castings many machining operations have been simplified or eliminated, weights have been reduced, production has been increased, and costs have been greatly lowered. Another prominent place in which advantage has been taken of the economies of the die-casting process for aircraft parts is in the production of AN connectors where low-grade aluminum die castings replaced parts machined from high-grade aluminum bar stock. In many cases the castings were stronger, much machining time was saved, and a comparatively small amount of secondary aluminum replaced a large amount of primary aluminum.

Alloys based on six common nonferrous metals have been commonly die cast—copper, aluminum, magnesium, zinc, tin and lead. Copper-base alloy die castings have been used only to a limited extent largely because of the extremely short die life, and also because

*Mr. Colwell has recently been appointed Coordinator of Conservation, U. S. Navy

—Photo, courtesy U. S. Army Signal

Signal Corps equipment utilizes large quantities of small die-cast parts

Production

of the critical shortage of the high-grade alloys required. Tin-base alloys for die castings will not be available while the bulk of the world's tin sources is in Japanese hands. Lead-base alloys are plentiful and can be used wherever their properties will suffice for the job to be done. Lead is heavier than other common metals and, although its tensile strength may be increased by alloying with antimony, arsenic, and combinations of other hardeners, it is still subject to cold flow. In many instances, however, its properties are satisfactory for the part at hand and the supply of material and casting facilities is ample.

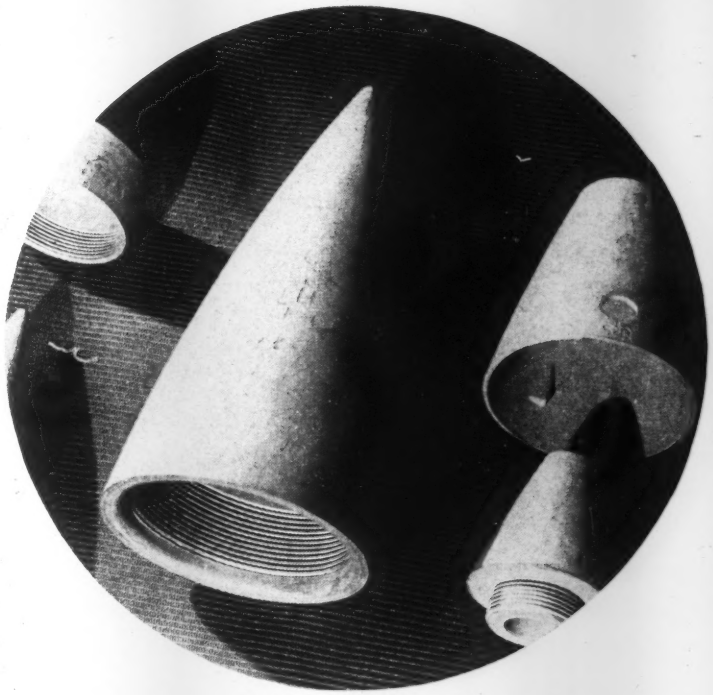
Although the production of magnesium die castings has not been large, the greater supply of that metal available at the present time makes such castings available for munitions uses. Capacity is being expanded and the supply of ingot is sufficient for the military applications.

"Low-grade" aluminum as specifically defined by Conservation Order M-1-i (containing four per cent copper and either iron or zinc in excess of one per cent) also is available for munitions parts. Special alloys based on secondary materials have been developed by the various specification-writing bodies. In munitions items where high-speed production is important and where manpower can be saved by the use of die castings, these alloys can be made available. The use of high-grade aluminum for castings, unless the application makes it absolutely necessary, is less desirable as this type of aluminum is required for sheet, bars, extrusions, etc.

The 99.99 per cent zinc necessary for die casting is also required for cartridge brass. Present indications are, however, that if the zinc die casting process is desirable as a means of time and labor economy in a military item, the zinc can be made available.

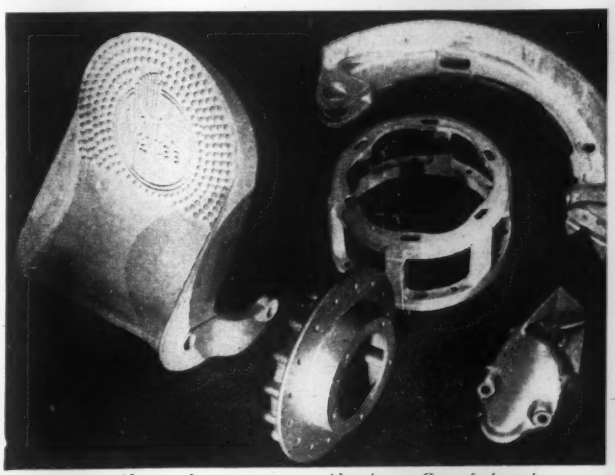
Both the Army and the Navy have made wide use of the die-casting process in fuse production. The body of one of these fuses used in tremendous volume is now a zinc-base die casting produced at a cost of about half that of the same part machined from brass bar stock. The Army Ordnance Department has retained W. J. During of the Precision Castings company as a die-casting consultant. With the use of the new low-grade aluminum alloy specified by Army Ordnance as AXS-679, this engineer has made wide use of aluminum die castings in ordnance fuses. With the increasing supply of magnesium, low-grade aluminum and zinc for munitions, wider use of the process will undoubtedly be made.

Zinc die castings are made of an alloy containing 4 per cent aluminum and a little magnesium, and perhaps copper. If the two impurities—tin and lead—are maintained within the limits set up by high-grade alloy specifications, castings of these alloys are strong and tough. At room temperatures their impact

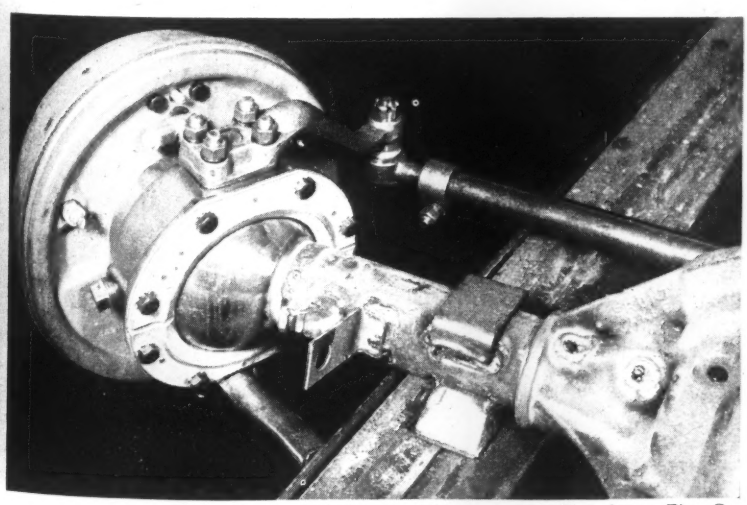


Above—Ordnance parts contain large numbers of die-cast parts such as these aluminum units

Below—Die-cast aluminum parts for aircraft provide accurately dimensioned, lightweight, high-production assemblies

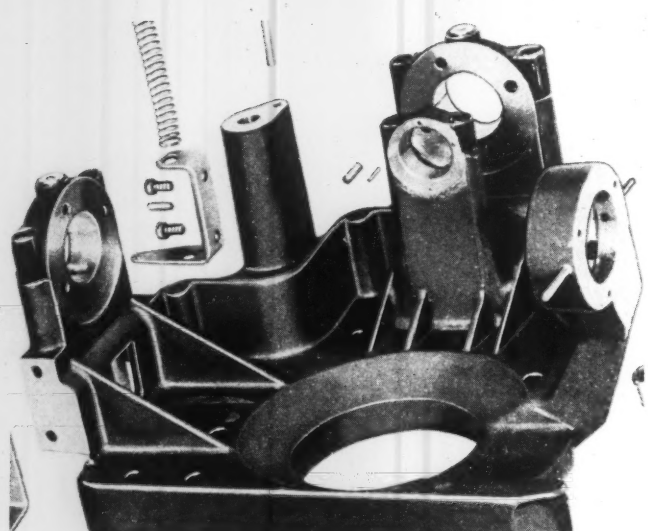


—Above photos, courtesy Aluminum Co. of America



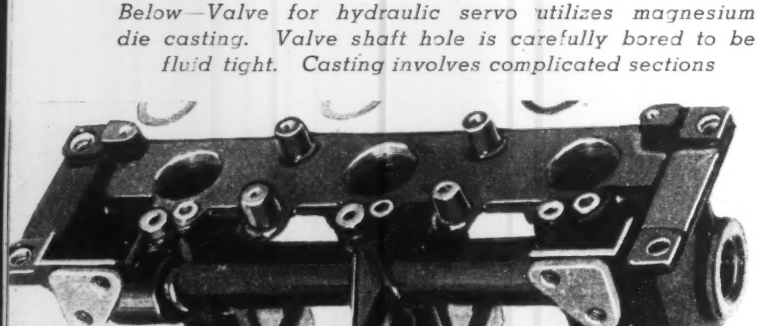
—Photo, courtesy New Jersey Zinc Co.

Zinc die-cast ring on front axle universal assembly of Army's Jeep is indicative of the severe service given these parts

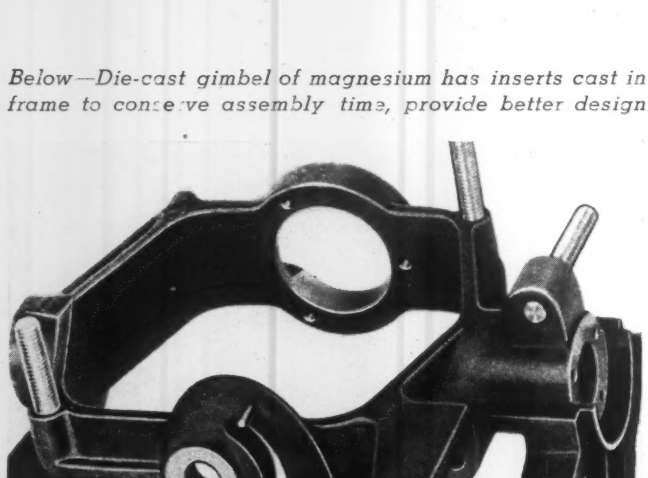


Above—Frame for gimbel mountings of automatic pilot is die-cast magnesium alloy. Dimensional stability is highly important, the machined surfaces being within .0001-inch—an accuracy which must be maintained

Below—Valve for hydraulic servo utilizes magnesium die casting. Valve shaft hole is carefully bored to be fluid tight. Casting involves complicated sections



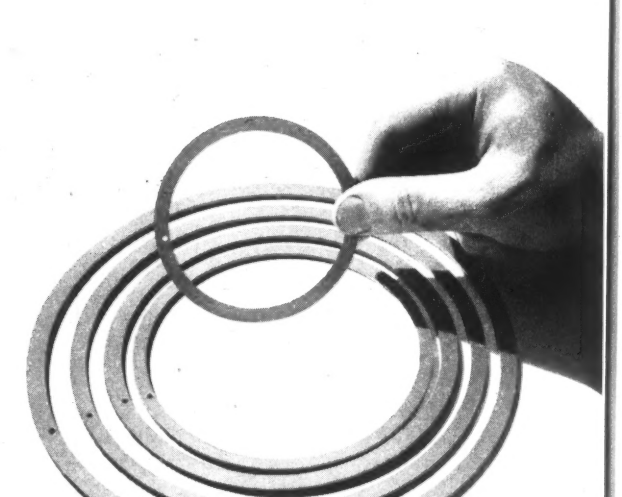
Below—Die-cast gimbel of magnesium has inserts cast in frame to conserve assembly time, provide better design



—Above photos, courtesy Jack & Heintz, Inc.

strength is five to ten times that of the best aluminum die castings. This impact strength drops rapidly at sub-zero temperatures but even at 40 degrees below zero it is approximately equal to that of most aluminum die-cast machine parts.

The maximum amounts of tin and lead which such alloys can safely bear are set up by the specifications at .005 and .007 per cent, respectively. If these limits are exceeded, zinc die castings are subject to a loss of impact strength and to change in dimensions on aging. Because these limits are so low it is difficult to make chemical determinations by the usual wet methods, and it has been found that the spectrograph offers the only practical means of controlling the composition quality. The controlled quality specification, therefore, drawn up by the American Society for Testing Materials requires spectographic analyses regularly, so that uniform specification compositions are assured.



—Photo, courtesy New Jersey Zinc Co.

Zinc die-cast bezels for submarine gages

The impurity contents of aluminum alloys are not as harmful as those of zinc. Consequently, control of composition of aluminum alloys to such minute limits is not essential. Many secondary aluminum alloys with impurities definitely controlled within reasonable limits are performing with entire satisfaction.

With proper gating and venting technique, and with regular X-ray control, any objectionable porosity of aluminum die castings can be eliminated. The controlled quality specification of the American Society for Testing Materials requires X-ray inspection, first to determine correct gating and venting of the die, and also as a production control to guard against possible subsequent porosity.

It is apparent that conservation of manpower is now one of our most important needs. The die casting process offers a means of mass production with minimum expenditure of manhours. Capacity is available, material for essential military items can be supplied, and W.P.B.'s certification plan offers a certainty of quality that previously could not be supplied. Undoubtedly the process will be given even greater responsibility before the war is over.

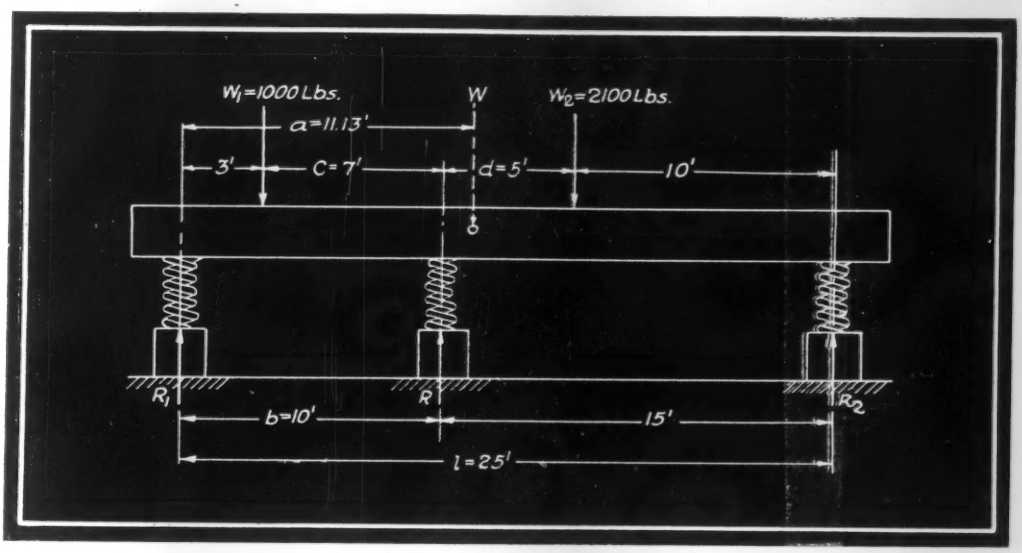


Fig. 1—Diagrammatic representation of a beam or shaft on supports which are relatively flexible compared with the beam. Reactions at supports depend on relative stiffness of beam and springs

Supporting Continuous Beams

By A. B. Cox

United Engineering & Foundry Co.

CONTINUOUS beams, which are beams having more than two supports, are used relatively infrequently by the general designer because of the known danger of high stresses being set up if any of the supports settle or deflect. Because of his relative unfamiliarity with the whys and wherefores of continuous beam design, the designer is sometimes at a loss to know what assumptions should be made and what degree of accuracy may be expected from his calculations.

In the following discussion a tested method of solving a special case is covered, but this special case throws so much light on continuous beam problems in general that it is worth the attention of designers in general. The method is reasonably simple and easy to understand and the results obtained are the limits of the reactions of the supports on the beam in case the supports are not entirely rigid. Results are compared with those obtained when the supports are rigid, indicating differences of considerable magnitude.

Because there are more than two unknown reactions at the supports of a continuous beam, while the ordinary conditions of static equilibrium (balance of forces and moments) yield only two independent equations, continuous beams are what is known as "statically indeterminate". In other words, the reactions depend not only on the external forces and moments but also on the deflections of the beam and of the supports. Thus the problem cannot be solved without a knowledge of beam and support stiffnesses.

Theoretical Conditions Seldom Encountered

Standard formulas for figuring multiple-support continuous beams assume that the supports are infinitely rigid, also that the cross section is uniform from end to end of the beam. However, it is seldom that such conditions are found in practice, especially the condition of rigid supports. These standard formulas assume that the reactions at the supports depend solely on the deflections of the beam and are, of course, applicable only to cases

where the deflections of the supports are extremely small compared with those of the beam itself.

At the other extreme is the case of a stiff beam mounted on relatively flexible supports. An example, *Fig.* 1, shows a comparatively rigid car frame supported on three axles by nests of springs. While the springs may deflect as much as an inch, the deflections of the frame itself probably do not exceed a few thousandths of an inch. Under such conditions the standard formulas are inapplicable, hence it is necessary to devise a different method for calculating the reactions at the supports.

Assuming the beam deflections are negligible, the derivation is as follows. First the location of the resultant of the external loads on the beam is found by taking moments about one end (at R_1), omitting the unknown reactions, and dividing the sum of the moments by the sum of the loads,

$$a=\frac{W_1(b-c)+W_2(b+d)}{W_1+W_2} \quad \ldots\ldots (1)$$

Substituting values from *Fig.* 1, a is found to be 11.13 feet. This is the position where a single foundation support would balance the applied loads. The method is applicable regardless of the number of loads and reactions and the step is included merely to simplify the resultant numerical calculations.

From the conditions of equilibrium, the sum of the reactions must equal the sum of the loads:

$$R_1+R+R_2=W_1+W_2=W \quad \ldots\ldots (2)$$

and the moments must balance, the moments being arbitrarily taken about R_2:

$$R_1l+R(l-b)=W(l-a) \quad \ldots\ldots (3)$$

A third equation, necessary for finding the three unknown reactions, is found from the position the loaded beam will assume due to deflection of the spring supports. The beam may be assumed to take the position shown in *Fig.* 2, the results being independent of the direction of slope at first assumed. The amounts of deflection per pound are taken as f_1, f and f_2 respectively at the three supports where the reactions are R_1, R and R_2. Corresponding deflections are f_1R_1, fR and f_2R_2. By proportional triangles (*Fig.* 2)

$$\frac{fR-f_1R_1}{b}=\frac{f_2R_2-f_1R_1}{l} \quad \ldots\ldots (4)$$

Equations 2, 3 and 4 can be simultaneously solved for the three unknowns R_1, R and R_2, with the following results:

$$R_1=\frac{fl(l-a)+f_2b(b-a)}{fl^2+f_1(l-b)^2+f_2b^2}\times W \quad \ldots\ldots (5)$$

$$R=\frac{f_1(l-a)(l-b)+f_2ab}{fl^2+f_1(l-b)^2+f_2b^2}\times W \quad \ldots\ldots (6)$$

$$R_2=\frac{fal+f_1(l-b)(a-b)}{fl^2+f_1(l-b)^2+f_2b^2}\times W \quad \ldots\ldots (7)$$

If the stiffnesses of the supports are equal to each other, $f_1=f=f_2$, these equations become

$$R_1=\frac{l^2+b^2-a(l+b)}{l^2+b^2-bl}\times\frac{W}{2} \quad \ldots\ldots (8)$$

$$R=\frac{l^2+2ab-l(a+b)}{l^2+b^2-bl}\times\frac{W}{2} \quad \ldots\ldots (9)$$

$$R_2=\frac{b^2+2al-b(l+a)}{l^2+b^2-bl}\times\frac{W}{2} \quad \ldots\ldots (10)$$

It is worth noting that the denominators of these fractions are alike.

Calculating the reactions for the problem in *Fig.* 1, using Equations 9, 10 and 11, it is found that $R_1=1095$ pounds, $R=1042$ pounds and $R_2=963$ pounds. The bending moment diagram is shown by solid lines in *Fig.* 3.

Treating this problem as one with rigid supports which are maintained in line with each other, the moment at the middle support must first be found. As given in

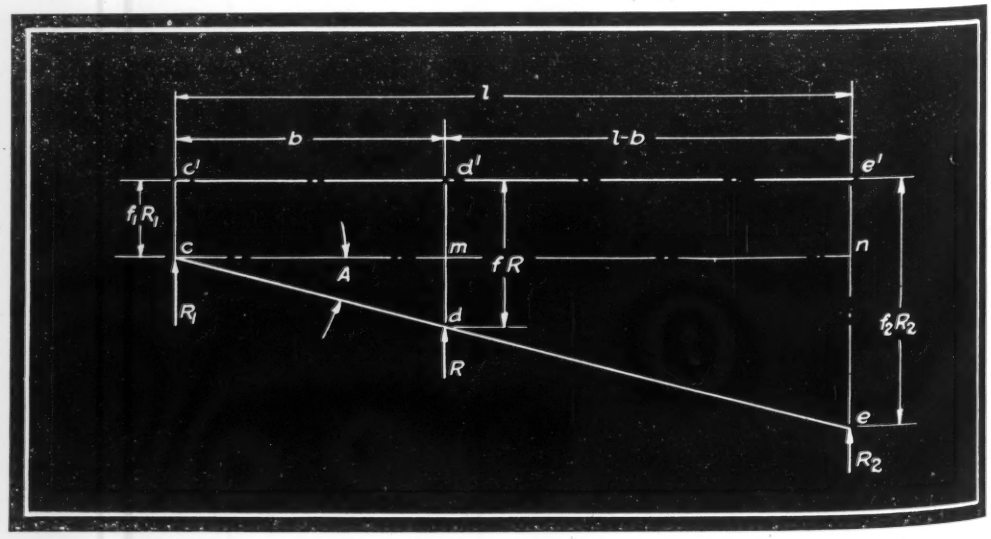


Fig. 2—When beam is loaded the supports deflect, allowing the beam to drop from position c' d' e' to c d e

Machinery's Handbook, (1)* this is equal to

$$M = -\frac{1}{2l}\left[\frac{W_1 c(b-c)(2b-c)}{b} + \frac{W_2 d(l-b-d)(2l-2b-d)}{l-b}\right] \quad \ldots\ldots (11)$$

where the notation is as given in *Fig.* 1. By taking moments to the left and to the right of the middle support, the end reactions are found to be

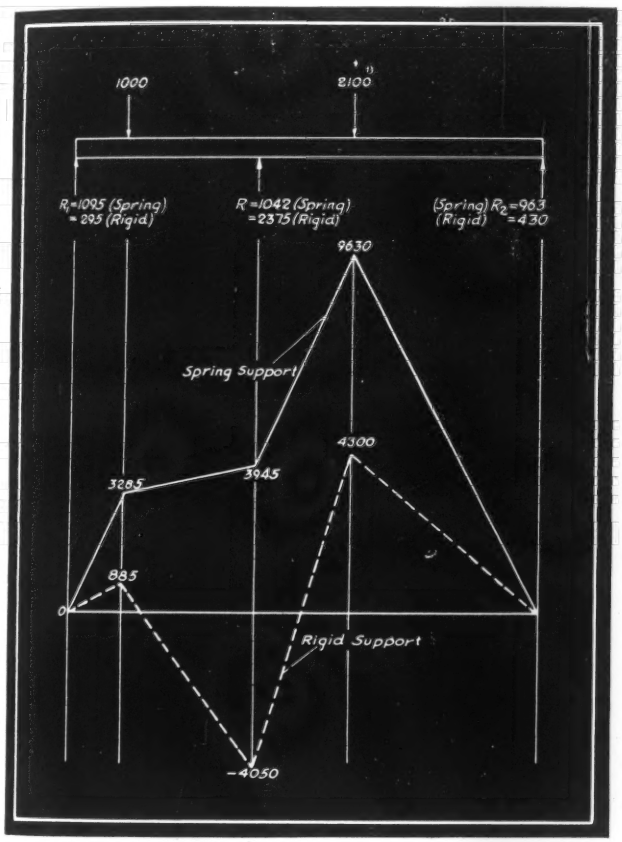


Fig. 3—Reactions and bending moments are compared for a rigid beam having spring supports, and a flexible beam on rigid, level supports

$$R_1 = \frac{M + W_1 c}{b} \quad \ldots\ldots (12)$$

$$R_2 = \frac{M + W_2 d}{l-b} \quad \ldots\ldots (13)$$

The reaction at the middle support, by difference, is

$$R = W_1 + W_2 - R_1 - R_2 \quad \ldots\ldots (14)$$

Calculating the reactions for the conditions in *Fig.* 1 except that supports are rigid, it is found, using Equations 11, 12, 13 and 14, that $R_1 = 295$ pounds, $R = 2375$ pounds, and $R_2 = 430$ pounds. The bending moment diagram is shown by broken lines in *Fig.* 3.

Because of the considerable differences in results revealed by this analysis, further consideration of the characteristics of continuous beams is worthwhile. It seems best to divide continuous-beam problems into three cases:

Case 1, in which the deflections of the supports are so small in comparison with the deflections of the beam that they can be neglected, that is, the supports can be considered infinitely rigid

Case 2, in which the deflections of the beam are so small in comparison with those of the supports that they can be neglected, that is, the beam can be considered infinitely rigid

Case 3, in which neither support nor beam deflections can be neglected.

For Case 1 the so-called standard formulas as commonly given in handbooks (1, 2), and textbooks on strength of materials (3, 4) can be used. For the special case discussed in this article, Equations 11, 12, 13 and 14 apply.

For Case 2 the method of analysis leading up to the derivation of Equations 5, 6 and 7 is the proper procedure.

Predicting Actual Reactions

For Case 3, unless the conditions of relative deflection are known accurately, probably the best solution is to work out the reactions by the formulas applying to both Case 1 and Case 2, then to decide as well as can be done by common sense how closely the actual reactions approach either one of the limits established. For instance, in *Fig.* 1 the reaction R_1 cannot be less than 295 pounds nor more than 1095 pounds, R cannot be less than 1042 pounds nor greater than 2375 pounds, and R_2 cannot be less than 430 pounds nor greater than 963 pounds. Where relative stiffnesses of beam and supports are known, more rigorous analysis is possible, using methods described in advanced textbooks on strength of materials (5).

Since no supports are ever absolutely rigid and since even small deflections of the supports can affect the reactions and bending moments so greatly, the preceding analysis is probably of greater importance to the general problem of multiple support beam design than might at first have been supposed.

For those interested in testing the accuracy of the results from the formulas applying to Case 2, a simple test set-up, using commercially obtainable spring scales for supports, buckets of water or sand for loads, and a two-by-four timber for a beam, provides a visual demonstration which may be more effective than a technical solution.

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2. Lionel S. Marks—*Mechanical Engineers' Handbook*, 4th edition, Page 471, 1941, McGraw-Hill Book Co. Inc., New York.
3. Arthur Morley—*Strength of Materials*, 7th edition, Page 227, Longmans, Green & Co., New York.
4. Fred B. Seely—*Resistance of Materials*, 2nd edition, Page 158, 1935, John Wiley & Sons Inc., New York.
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*References in parentheses are listed at end of article.

The Shape of Thing

Part II—Division of Rectangles

By R. S. Elberty
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DESIGNERS continually encounter the problem of locating machine elements on large surfaces. Since this involves a division of these surfaces, principles contained in dynamic symmetry can serve as a guide for the location of the elements. Often nameplates, pushbuttons, or machine doors can be placed from the appearance standpoint alone. However, rectangles may be divided into many dynamic proportions and this system therefore provides for considerable freedom of choice.

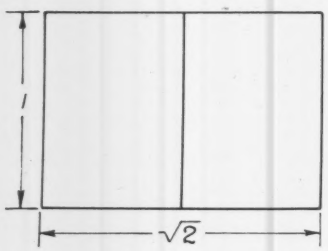


Fig. 10—Root 2 Rectangle divides into two root 1/2 rectangles

Thus it is possible to locate machine parts according to their function and still retain a dynamic location or division of the surfaces on which they are mounted.

RECIPROCAL SHAPES: Areas may be divided in numerous ways, the arithmetic method of division being the simplest. For example, a checkerboard is an arithmetic division of a square into 64 similar squares. The common point in static and dynamic division of rectangles may be obtained by the utilization of the reciprocal rectangles. This principle may be expressed by the equation

$$\sqrt{n} = \frac{n}{\sqrt{n}} = n \times \frac{1}{\sqrt{n}}$$

If n is selected to equal whole numbers, starting with 2, a series such as $\sqrt{2} = 2 \times 1/\sqrt{2}$, $\sqrt{3} = 3 \times 1/\sqrt{3}$, etc., is obtained. These define a relationship between the basic root rectangles and their reciprocals. The rule may generally be stated that "A root n rectangle may be divided into n equal root $1/n$ rectangles."

In *Fig.* 10 is shown a root 2 divided into two root ½ rectangles. The root 2 is the only rectangle that can be divided into 2 rectangles similar to the original. Thus *Fig.* 10 includes three similar rectangles and their relationship is pleasing in its simplicity. In like manner *Fig.* 11 shows a root 3 divided into three root 1/3 rectangles. *Fig.* 12 is a similar division of a root 4 and *Fig.* 13 shows five divisions of a root 5, each equal to a root 1/5. *Figs.* 10, 11 and 12 are all pleasing in that they are divided into arithmetic and geometric relationships.

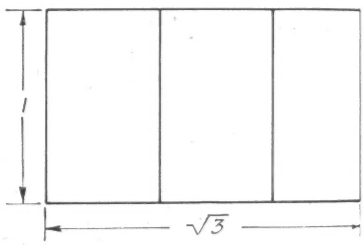


Fig. 11—Three root 1/3 rectangles are formed from a basic root 3 rectangle

There is a principle of design applying to arithmetic divisions which states that an odd number of divisions is more pleasing than an even number since the visual center of such a design is easily found. This principle detracts from the value of the root 2 and root 4 rectangles for purposes of arithmetic division, but root 3 and root 5 rectangles gain.

Fig. 14 shows the application of these principles of division of rectangles to machine covers. For functional

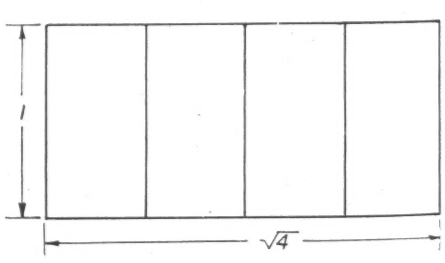


Fig. 12—Division of a root 4 rectangle effects shapes similar to those in Fig. 10

To Come

consideration the machine bed has six sides, making the machine a root 3 composition. The large door is a root 3, the two side doors are root 1/3 rectangles. The natural division of these rectangles is shown by locating the mounting screws to divide the doors into three parts. The long narrow door at the top is similar to a root 12 and is divided to form two small root 3 rectangles. The illustration shows a full-sized wood model of a machine tool designed for the production era following the war.

This, then, is the reason for giving importance to the reciprocal rectangles. They are more than similar rectangles; they are special similar rectangles that can be used for the arithmetic and geometric division of the root 2, root 3, root 4, and root 5 rectangles. The basic root rectangles also take on interest for the machine designer, since the arithmetical grouping of machine elements permits a maximum of standardization of parts.

THE DIAGONAL: Plane geometry is based mainly on triangles; therefore, the division of a rectangle into triangles forms a dynamic or geometric method of approach. In *Fig.* 15, *BD* is a diagonal of the root 2 rectangle *ABCD*. Diagonal *EC* is perpendicular to *BD*. Triangles *EBG*,

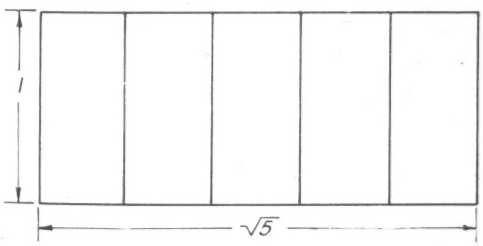


Fig. 13—Root 5 rectangle illustrates that odd numbers have advantages over even as shown in Fig. 12

BCG, *CDG*, *ECB*, and *DBA* are all either similar or symmetrical. Therefore $GC : BC = BC : EC$; $BG : BC = BC : BD$ and $EB : BC = BC : CD$. Since $BC = 1$, then $GC = 1/EC$; $BG = 1/BD$; $FB = 1/DC$. The rectangle *EBCF* is the reciprocal of *ABCD*, in this case *EBCF* being a root 1/2. Because the point *G* defines the diagonal and its perpendicular, this point is important in the geometric division of any rectangle.

Since there are two diagonals and two perpendiculars for each diagonal, there are four points within a rectangle that determine its division by means of triangles. This construction is shown in *Fig.* 16. These lines apply to any rectangle and photographers sometimes scribe them

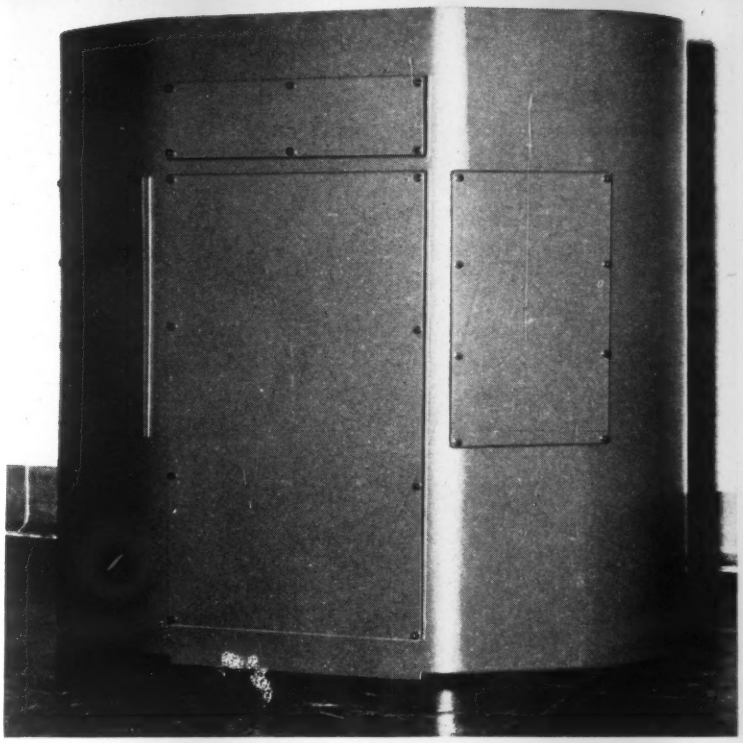


Fig. 14—Application of division of rectangles to machine panels utilizing root 3 and root 1/3 rectangles

on the camera finder to indicate a good composition in their pictures. Many artists have experimented successfully with figure drawings in which all lines are limited to horizontals, verticals and parallels to the two diagonals and the four perpendiculars.

A scroll based on a root 2 rectangle is shown in *Fig.* 17. The diagonal of the reciprocal is perpendicular to the diagonal and the lines of the scroll follow the sides of similar root 2 rectangles determined by the diagonal construction. This figure also suggests that the diagonal construction can be used for creating larger similar rectangles, a system that has been used as an enlarging scheme superior to the static or arithmetic method of enlarging by squares.

Diagonals Aid Construction of Reciprocals

In the division of rectangles, the diagonals and the diagonal of the reciprocal are at right angles. The mean and extreme ratios obtained from this construction form a purely dynamic division of rectangles as compared with arithmetic divisions. They also form another method for the construction of the reciprocal rectangles. These lines define a relationship between any rectangle and its reciprocal and are important considerations in the division of rectangles.

SUPPLEMENTS, COMPLEMENTS AND THE SQUARE: No discussion of the division of rectangles could be complete without mention of the division of the square. In *Fig.* 18

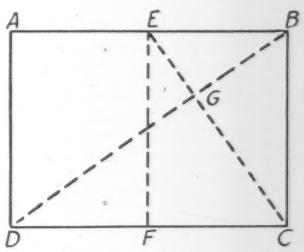


Fig. 15—Intersection of perpendicular diagonals is important point in geometric division

the rectangle *ABCD* is a root 2, *EFBA* is its complement and *EFCD* is a square. A new definition may be introduced at this point: "A Supplementary Rectangle is one which if subtracted from a rectangle will leave a square as the remainder." This definition is new to dynamic symmetry, but such rectangles are used and they merit the dignity of a name and definition.

In *Fig.* 18 the rectangle *EFBA* is a complement root 2 and is composed of a supplement root 2 and the square *GFBK*. This construction can be extended as shown by the dotted lines of *Fig.* 18 and it may be applied to division of a square on the basis of the root 3, root 4, root 5,

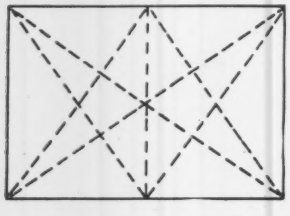


Fig. 16—Two diagonals and two perpendiculars for each diagonal determine four points for division by triangles

or any other rectangle. Since the supplement root 4 is a square and the complement root 4 is another root 4, this division of a square on a root 4 basis is static in nature and lacks the interest obtained from a purely dynamic division.

At best, a square is uninteresting, but interest can be added by the manner in which the square is divided. Certain complex rectangles may be selected to offer better possibilities here than the basic root rectangles, but the principles of application are the same since they embody the use of complements and supplements. Static division of a square will divide it into other squares, root 4 or static rectangles. A square may be more interestingly divided into dynamic rectangles and squares as indicated in *Fig.* 18.

Divisions of Surfaces Should Be Related

SIMILAR RECTANGLES: Machine doors offer a common method of dividing or breaking a larger surface of the machine. The shape of any door should have some rela-

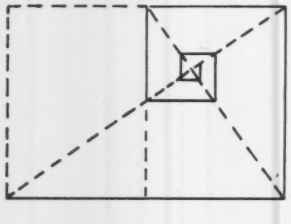


Fig. 17—Geometric scroll based on root 2 rectangle

tion to the shape of the surface to which it is applied. This may be a complement, a supplement, or a similar shape, such as a reciprocal.

If lines are drawn from any point to the four corners of a rectangle, these lines determine an entire group of similar rectangles. *Fig.* 19 shows a root 5 rectangle, point *T* being the intersection of the diagonal and one of its perpendiculars. The smaller rectangle is a root 1/5 and its size and location divides the root 5 into several interesting and pleasing parts. In *Fig.* 19, the root 5 might be the column of a machine tool, the root 1/5 being a door to the control compartment. If such were the case, the door handle should be located at point *T* and should be a similar shape to the other rectangles.

The root 5 and root 1/5 have been selected for *Fig.* 19, since there are relationships in these rectangles not found in the other basic root rectangles. A hint of this appears in *Fig.* 19 when the dotted lines are considered. The root 1/5 then divides the root 5 into two unity squares, *LEDA* and *KFEL*, and four root 1/5 rectangles—*LNBA*, *NPCB*, *KMNL* and *MOPN*—as well as numerous complements *NEDB*, *PEDC*, etc., and similar rectangles such as *JIMK* and *HGFO*. Here is a structural richness to inspire and help the machine designer. A door so applied adds to the beauty of the machine by adding to the unity of the design.

Figs. 20 and 21 show a Landis cylindrical grinder, a design based on the root 2. The shape of the machine is repeated in the kneehole, headstock, wheelbase, and bed of the machine. *Fig.* 21 can be compared with *Figs.* 15 and 17, the division of the machine into bed, wheelbase, and spray guard being at the intersection of the diagonal and a perpendicular. Arithmetic division of the bed into three doors was dictated by functional reasons; two doors would have been the simplest correct division from the dynamic viewpoint.

Diagonal Constructions Achieve Rich Results

Division of rectangles can be on a simple arithmetic basis, a common example being the checkerboard, as previously mentioned. The dynamic division of rec-

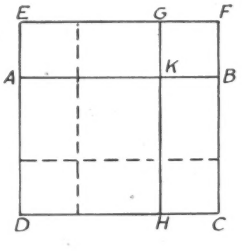


Fig. 18—Left—Division of square based on root 2 rectangle and its complement

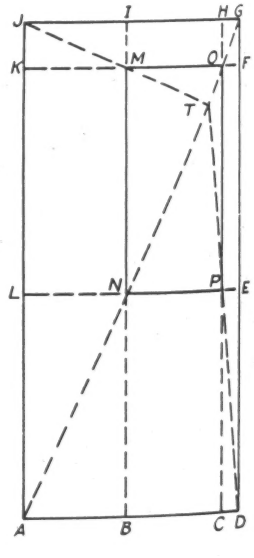


Fig. 19—Right—Root 5 rectangle showing possible location of door and handle. Two unity squares are also incorporated

tangles is based on a right-triangle construction obtained from the diagonal and a perpendicular to the diagonal. While this construction applies to any rectangle, it is in the true dynamic rectangles that it achieves the richest results. The cause for this is found in the importance of the reciprocal and the added relation the reciprocal

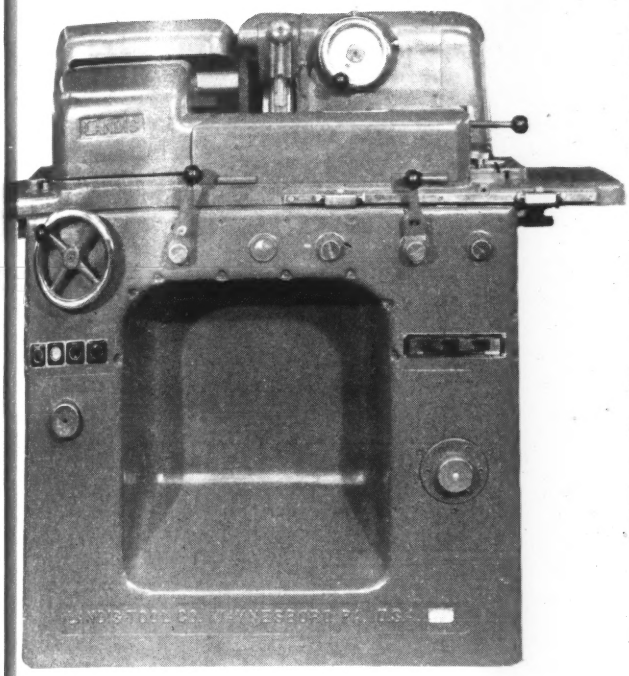
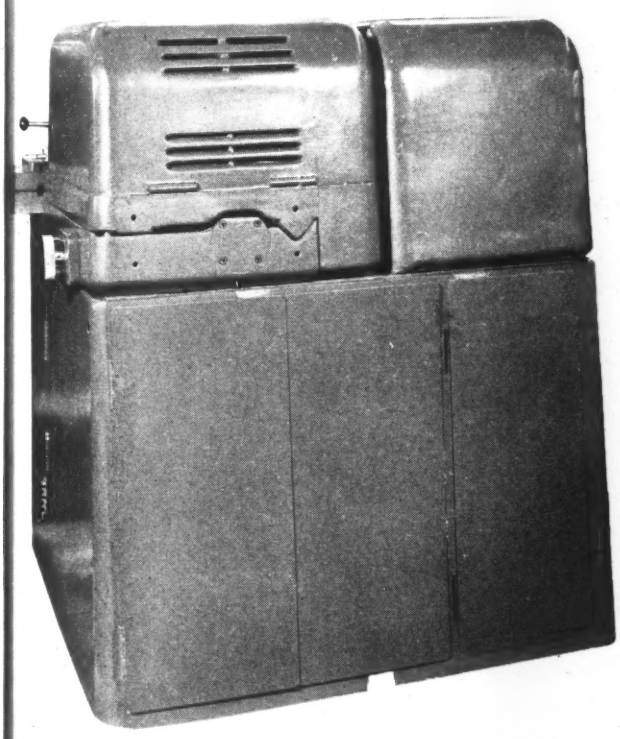


Fig. 20—Root 2 rectangle is utilized for shape of machine and component parts. Shape is repeated in the kneehole, headstock, wheelbase and bed of machine

Fig. 21—Back view of machine shown in Fig. 20. Division into bed, wheelbase and spray guard is at intersection of diagonal and its perpendicular



of a dynamic rectangle bears to the whole.

Diagonal construction offers an entirely new field to the designer who has been using purely arithmetic methods of division. The static system need not be discarded, it may be retained as a special case of dynamic division. But the dynamic division of rectangles will give the designer a greater freedom of choice with assurance that the result will be basically correct.

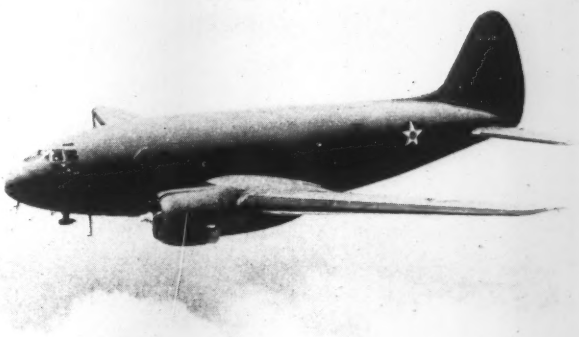
(*Continued in next issue*)

CORRECTION: In Part I of this series (M. D. August) the equations on Page 116 for proof of the construction of *Fig.* 7 should be corrected to read:

$$(AE):(AD)=(AB):(AC),\ (AB)=\frac{1}{\sqrt{2}}$$

Most Efficient Cargo Plane

CURTISS COMMANDO planes were recently classified by the Office of War Information in its report on air transport as the most efficient cargo carrier of its type. Used by the Army Air Force for speeding troops, jeeps, light tanks and field artillery to America's widely



scattered battle zones, the Commando weighs about 50,000 pounds fully loaded and is powered with two 2,000-horsepower engines. Illustrating its role in the war, the Air Force announced recently that a large number of Commandos had landed in India after a record 15,000-mile flight in 4½ days from America via Africa on what was termed "the longest and biggest mass flight in transport history".

Since the announcement that the War Department has canceled contracts for production of the experimental C-76 wood type of transport, the Louisville plant of Curtiss-Wright will aid in producing these Commandos.

AUTOMATIC WRAPPING machines are being produced to wrap submachine gun magazines in a greaseproof waxed paper, heat-sealed on both ends. The machine is expected to wrap sixty magazines a minute.

Progressive Changes in Fatigue Failure

By J. B. KOMMERS

University of Wisconsin

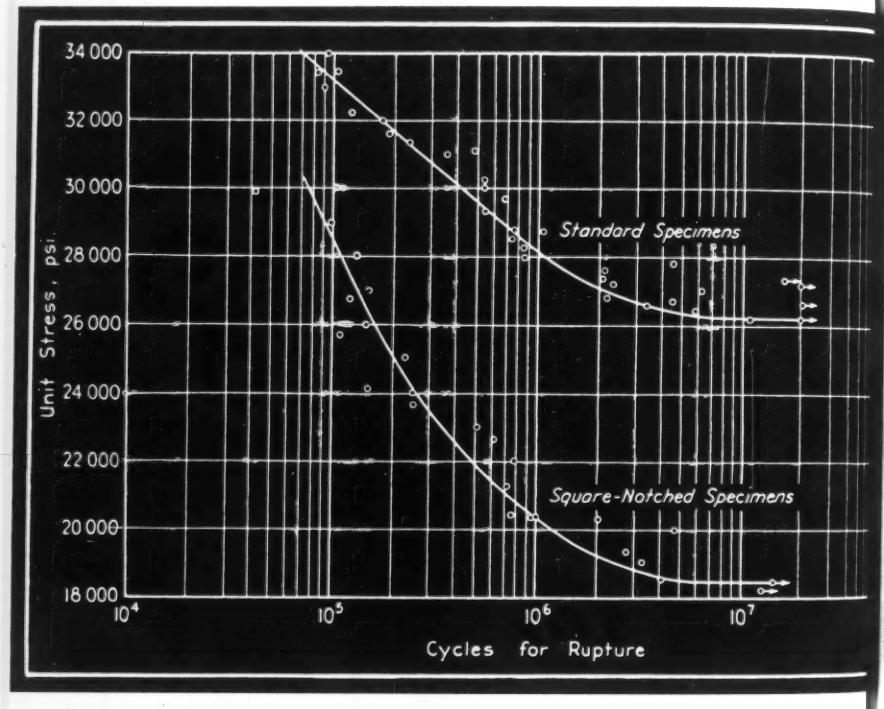


Fig. 1—S-N diagram shows fatigue characteristics of annealed ingot iron. The point of this material is 22,700 pounds per square inch, considerably less than the endurance limit which is 26,200 pounds per square inch

WHY a material that is subjected to repeated stresses above the endurance limit finally develops a crack and fails is a question that has puzzled engineers for years. Changes must occur in the material during the progress of the test, otherwise there would be no failure. Inelastic action and permanent deformation, as usually thought of, are not necessarily criteria for fatigue failure. For example, the maximum stress in a direct-stress cycle that is not completely reversed may be above the tensile yield point, so that at the first application of the upper limit of stress there is a large permanent set. Even in this case, if the lower limit of stress is properly chosen, fatigue failure will not occur. On the other hand, under completely reversed stresses, there may be no recognizable phenomena which would make one suspect that failure will take place, and yet failure occurs.

One of the main purposes of the tests under discussion was to determine what changes occur during the progress of a fatigue test. The method employed was to subject specimens to overstress for various numbers of cycles less than required for failure, and then to determine the new endurance limits. By this method the changes that may be proceeding in the material are measured by the change in the endurance strength of the material.

Understressing tests show the changes that occur during a fatigue test when the stress is below the endurance limit. In general, both overstressing and understressing tests show that the endurance limit is being changed by such stressing. Apart from the increase of endurance limit that understressing may confer on a material, is the increased number of cycles of stress that may be withstood successfully after understressing. Even when the increase of endurance limit is only of the order of 25 or 30 per cent, the increased "life" at higher stresses, as measured by the number of cycles, may be of the order of 20,000 per cent.

Annealed ingot iron was chosen for some of these tests because it is homongeneous and has unusual fatigue properties. *Fig.* 1 shows the S-*N* diagrams for smooth and square-notched specimens.

In making overstressing tests, a series of specimens was subjected to an overstress of, say, 10 per cent above the endurance limit for a certain cycle ratio. The term cycle ratio means the ratio of the number of cycles used with the overstress to the total number of cycles which would cause failure at this stress. After overstressing, the load on the specimen was reduced in order to determine the new endurance limit. Damage due to overstress was expressed by the percentage that the new endurance limit was below the virgin endurance limit.

Upper part of *Fig.* 2 shows percentage of damage plotted against cycles of overstress, for standard smooth

* Abstract of a paper presented at the forty-sixth annual meeting of the A.S.T.M. in Pittsburgh.

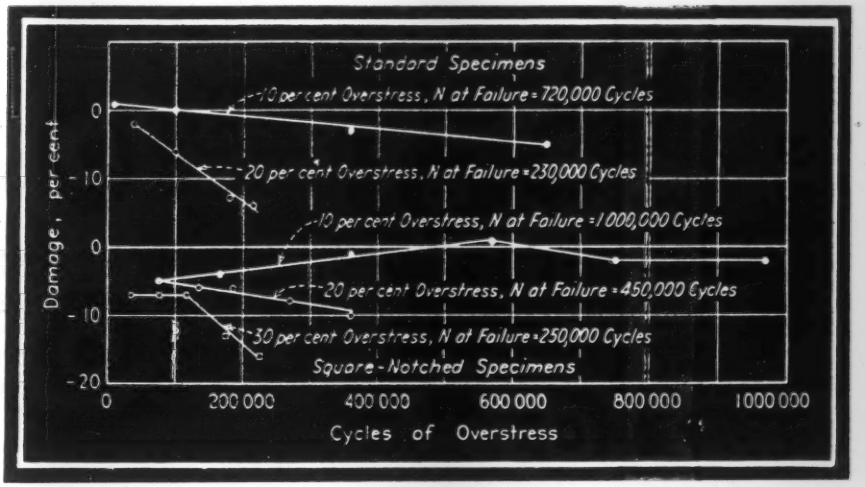


Fig. 2—Damage curves for annealed ingot iron show reduction in endurance limit due to overstress

specimens of annealed ingot iron at 10 and 20 per cent overstress. For 10 per cent overstress the 720,000 cycles shown on the graph represents the average cycles for failure at 28,800 pounds per square inch (10 per cent above the endurance limit of 26,200 pounds per square inch), as determined from the S-N diagram, *Fig.* 1. Lower part of *Fig.* 2 shows damage curves for square-notched specimens at 10, 20, and 30 per cent overstress. An attempt was made to stress smooth specimens at 30 per cent overstress, but this was so far above yield point that they failed by bending.

For the smooth specimens, straight lines seem to fit the experimental points and there is some evidence that endurance limit is slightly increased at small values of cycle numbers. These specimens are not very susceptible to damage due to overstress, because even at 20 per cent overstress the damage is less than 15 per cent at cycles larger than 207,000 or cycle ratios above 90 per cent (cycle ratio being ratio of cycles to cycles causing failure).

Annealed ingot iron has a curious property under fatigue which the author has not found in any other ferrous metal: Although the yield point in tension is 22,700 pounds per square inch, the endurance limit under reversed bending stresses is 26,200 pounds per square inch, or 15.4 per cent above the yield point. It has often been pointed out that there is no correlation between the endurance limit and the elastic properties as found in a static test. When ingot iron is subjected in fatigue to the endurance limit stress, there must be inelastic action because the stress is above the yield point. However, as the test proceeds, the material recovers so that it finally becomes perfectly elastic well above original yield point.

In *Fig.* 2 at 10 per cent overstress for the square-notched specimens, the damage curve exhibits a curious recovery of endurance limit with increased number of cycles, after which there is progressive recovery until at a cycle ratio of 58 per cent (580,000 cycles) the endurance limit shows an increase of 1 per cent. Thereafter there is again some decrease, which remains small, however, even up to a cycle ratio of 97 per cent (970,000 cycles). This is the only definite case of recovery that the author has found in any overstressing tests. For 30 per cent overstress on square-notched specimens, the damage curve shows no actual recovery, but the tendency toward recovery seems to be indicated by the fact that the curve remains horizontal up to a cycle ratio of about 47 per cent (117,500 cycles).

In *Fig.* 3 the solid lines represent the ordinary S-*N* diagrams for standard and square-notched specimens of annealed ingot iron. For the standard specimens the two horizontal rows of points represent the results which were obtained at

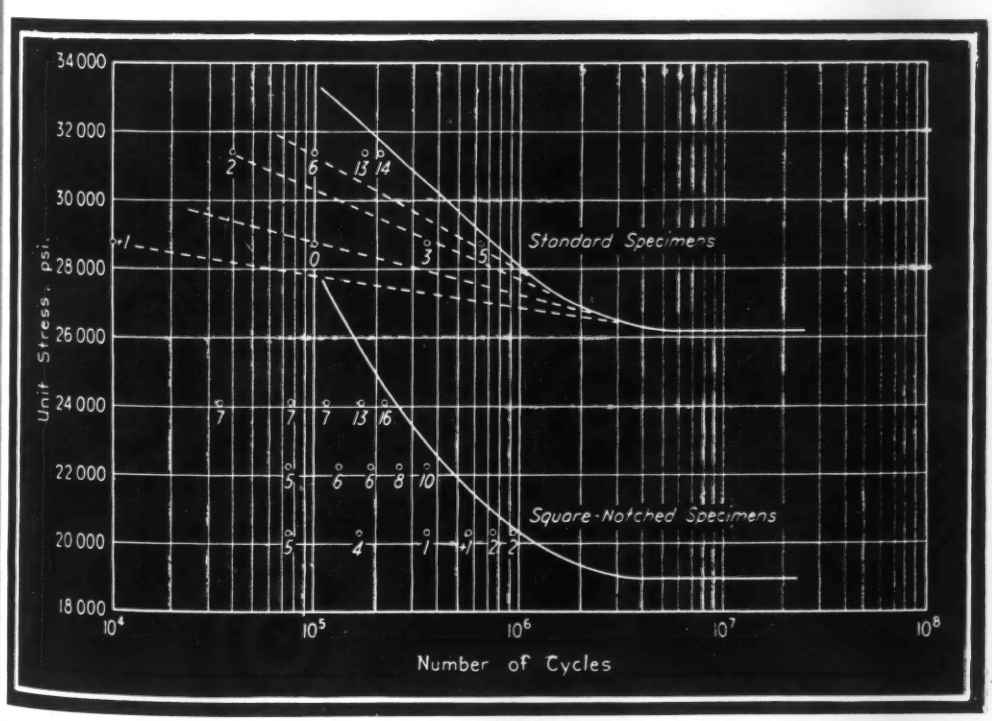


Fig. 3—Per cent damage is indicated by numbers alongside plotted points. Broken lines denote approximately constant percentage of damage

10 and 20 per cent overstress. The numbers adjacent to the plotted points represent the percentage of damage obtained at the various numbers of cycles. An attempt has been made to draw dashed lines which might correspond approximately to an increase of 1 per cent in endurance limit, and decreases of 0, 2 to 3, and 5 to 6 per cent.

In the lower graph of *Fig.* 3 the horizontal rows of points represent damage results obtained on square-notched specimens at 10, 20 and 30 per cent overstress. The numbers adjacent to the plotted points represent the percentage of damage found at the given stress and number of cycles. Because the damage curves in *Fig.* 2 did not show continually increasing damage with increase in number of cycles, it is evident that it is not possible to draw simple damage lines as was done by the dashed lines in the upper graph of *Fig.* 3. This is especially true for the damage results obtained at 10 per cent overstress.

From the overstress results, it may be concluded that a material finally fails at a stress above the endurance limit because the endurance limit is being changed while the test proceeds. For some materials there may be actual recovery of endurance during part of the test, while for others the endurance limit decreases gradually throughout the test, with a more rapid decrease before failure. For still other materials the damage may remain fairly constant for most of the test, with the probability that the damage increases rapidly just before failure.

This last-mentioned property of delayed damage would evidently be valuable for machine parts such as rear axle gears in automobiles, in which the working stress is deliberately chosen above the endurance limit. This is done because it is known that the life of the gears is greater than the life of the car.

The fact that for certain materials at small numbers of cycles the then existing endurance limit is above the ordinary endurance limit, that for square-notched specimens of ingot iron there was actual recovery of endurance limit, and that for some other materials there is delayed damage, seems to point to the conclusion that a destructive action and a strengthening action proceed simultaneously. Evidently for stresses above the endurance limit the destructive action finally prevails and causes failure.

A surprising, and at the same time an encouraging, fact brought out by the overstress tests is that the materials are not damaged as much as might be expected by overstresses, and that they can withstand overstress for a large proportion of the normal life without a really serious reduction of endurance limit. It should be remembered, however, that while this may be true for 10 per cent or overstress, it is not true for heavy overstress.

In 1930 the author reported understressing tests on cast iron of 20,000 pounds per square inch tensile strength.

TABLE I
Effect of Understressing on Endurance

Stress Used in Understressing (psi)	Number of Cycles of Understressing	Increase in Endurance Limit (per cent)
26,000	5,000,000	6.1
26,000	10,000,000	6.1
26,000	20,000,000	6.9
26,000	30,000,000	8.0
26,000	40,000,000	19.0
26,000	60,000,000	23.0

After understressing at 9000 pounds per square inch (endurance limit 9300 pounds per square inch), it was found that the endurance limit could be increased 25 per cent in 15 million cycles. Beyond 15 million cycles, up to 40 million cycles, there was no further strengthening.

In the present experiments, similar tests were made on standard smooth specimens of annealed ingot iron having an endurance limit of 26,200 pounds per square inch.

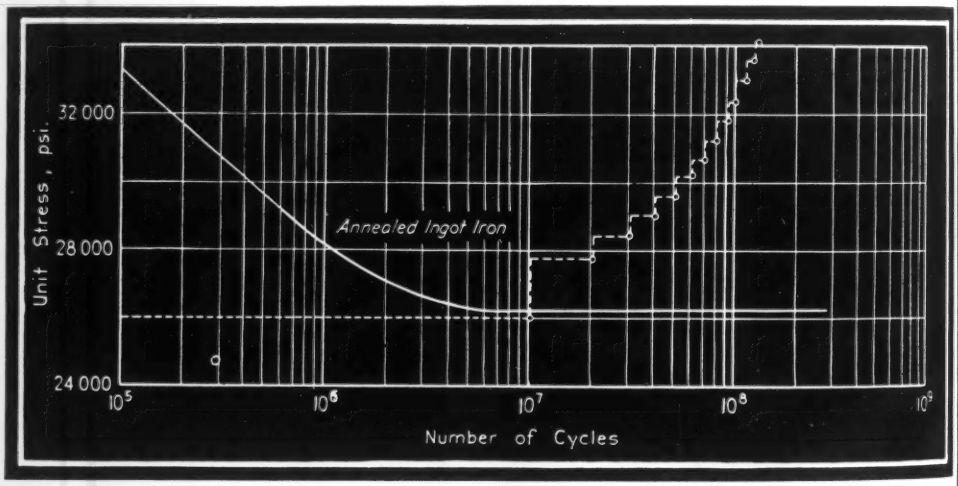


Fig. 4 — Understressing followed by coaxing (adding load increments at intervals) greatly increases endurance strength and life

unit stress of 26,000 pounds per square inch was applied for various cycles up to 60 million. In these tests the higher stress applied after understressing was kept constant and a maximum run of 20 million cycles was used for those specimens that did not fail. The results, shown in TABLE I, indicate that the increase in endurance limit with increase of understressing cycles is not regular. Between 30 and 40 million cycles there is a considerable jump in fatigue strength up to 19 per cent, and at 60 million cycles there is a further increase up to 23 per cent. These results indicate that annealed ingot iron, in contrast with cast iron, requires comparatively long runs of understressing to obtain substantial increases of fatigue strength. Because of the lack of material, only a few tests were made at 80 million cycles of understress, but these seemed to indicate that there was no further increase in fatigue strength.

In determining the new endurance limit in the above tests, a number of specimens did not fail. These specimens were tested to failure by adding ¼, ½ or 1 pound

(Concluded on Page 196)

When Does Good Engineering Constitute Invention?

By George V. Woodling

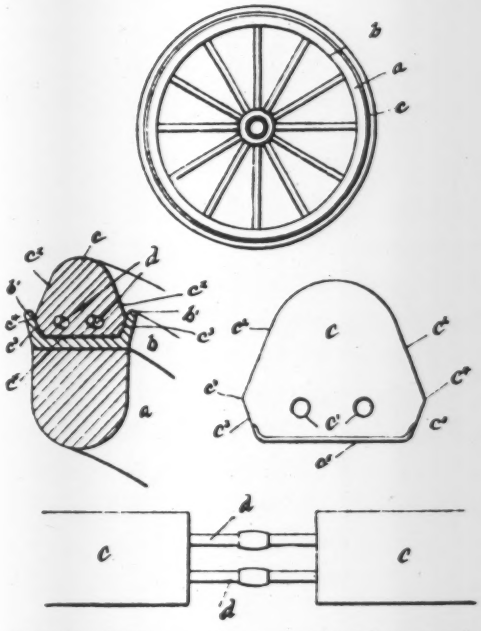


Fig. 1—Absence of cement in the attachment of this rubber tire to the wheel rim was held to be patentable because it permitted the tire to creep

ACCORDING to the recent report of the National Patent Planning Commission: "The most serious weakness in the present patent system is the lack of a uniform test or standard for determining whether the particular contribution of an inventor merits the award of the patent grant. The patent statute itself is quite specific. R. S. 4886 provides that a patent may be obtained by 'any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter, or any new and useful improvements thereof . . .' The difficulty in applying this statute arises out of the presence of the words 'invented' and 'discovered'. Novelty alone is not sufficient, nor is utility, nor is the final accomplishment. There must also be present some mysterious ingredient connoted in the term 'invented'."

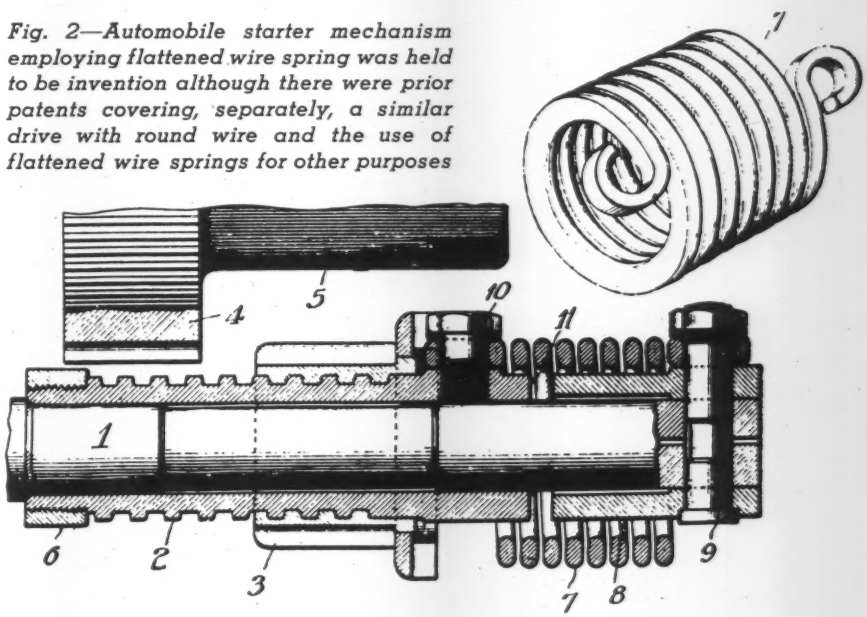
Not all improvements possess the dignity of invention. Some of them do not rise above the level of the ideas created by a mechanic in the course of his daily work. Such ideas and improvements are legally designated as being the product of *mechanical skill*, as distinguished from *invention* which is produced by the exercise of inventive faculties. Mechanical skills are not patentable because the government is interested only in granting patents for subject matter which truly promotes the progress of science.

To test whether or not a new device merits the award of the patent grant, it must be compared with preceding devices. Difficulty is encountered in applying the test for the reason that after seeing the new device and comparing it with the old, there is a natural and human tendency to belittle the ingenuity involved in producing the new device and to hold it to be a mere application of mechanical skill. Judges who are called upon to make the final decision are aware of this tendency and try to avoid it. Observe the following language taken from a United States Supreme Court decision which involved the question of whether the rubber tire shown in *Fig.* 1 was invention:

> "Knowledge after the event is always easy, and problems once solved present no difficulties —indeed, may be represented as never having had any, and expert witnesses may be brought forward to show that the new thing which seemed to have eluded the search of the world was always ready at hand and easy to be seen by merely skillful attention. But the law has other tests of the invention than subtle conjectures of what might have been seen and yet was not."

Probably the greatest difficulty in establishing a standard of invention lies in the fact that the hundreds of examiners in the Patent Office, the various federal judges

Fig. 2—Automobile starter mechanism employing flattened wire spring was held to be invention although there were prior patents covering, separately, a similar drive with round wire and the use of flattened wire springs for other purposes



[a] "The American Patent System". The Commission is made up of the following members: Charles F. Kettering, *Chairman*; Chester C. Davis; Francis P. Gaines; Edward F. McGrady; Owen D. Young; Andrey A. Potter, *Executive Director*; Conway P. Coe, *Executive Secretary*.

throughout the land and the judges of the Supreme Court must look upon the question of invention with eyes taught by ingenuity of the thing created. What may seem to be invention to one examiner or to one judge may not be invention to anotner. Some hold to a high standard while others advocate a low standard, resulting in much confusion.

Patentable Means Enforceable by Courts

The Patent Office has been accused of having a lower level than the courts because a number of the patents subsequently involved in litigation are declared invalid by the courts. Therefore when a device is spoken of as being "patentable", it is understood to be one that is enforceable by the courts, and not merely one for which the Patent Office has granted a patent. It often has been urged that the Patent Office be more stringent in the examination of applications for patents to avoid the granting of patents upon minor or petty improvements which later have to be declared invalid by a court. On the other hand, a great deal has been written condemning the high standard maintained recently by the United States Supreme Court. Records show that substantially every patent that has reached the Supreme Court during the past few years has been declared either invalid or noninfringed.

It has been argued that so far as ultimate results are concerned, our patent system would operate just as well, maybe better, if the element of invention were simply forgotten. The sole test of patentability would then hinge upon whether the device was *new* and *useful*. This argument is based upon the fact that it makes little difference from the industrial or commercial point of view whether the new device sprang from mere mechanical skill or from inventive skill. If the device is commercially good the public will want to have it, and the commercial success or failure will not depend upon the low level of the birth of the invention.

Novelty and Invention

Abolition of the element of invention would not solve the difficulty since the question of what is new as distinguished from that which is a colorable variation of what is old, is usually the very question at issue. Thus it is seen that to test whether a device is new also involves the problem of determining how far it differs from prior devices.

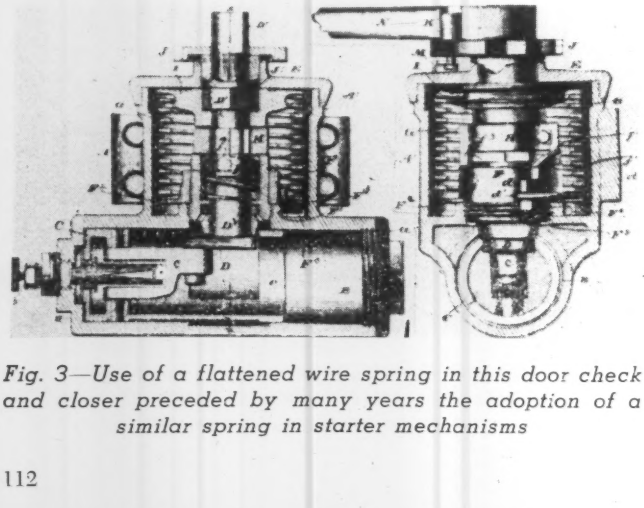


Fig. 3—Use of a flattened wire spring in this door check and closer preceded by many years the adoption of a similar spring in starter mechanisms

This is, from a practical point of view, the same thing as determining whether or not "invention" is present. It therefore appears that to superimpose the element of invention upon the element of novelty or newness draws one somewhat nearer to an appreciation of the true advancement made in the art.

Accordingly the requirement that a device not only be new and useful but also be "invention", as set forth by the present statutes, prevents the granting of a patent for every trifling device. The courts are aware of the hazards which would be imposed upon industry if such patents were granted, as indicated by the following quotation of the Supreme Court:

> "The design of the patent laws is to reward those who make some substantial discovery or invention which adds to our knowledge and makes a step in advance in the useful arts. Such inventors are worthy of all favor. It was never the object of those laws to grant a monopoly for every trifling device, every shadow of a shade of an idea, which would naturally and spontaneously occur to any skilled mechanic or operator in the ordinary progress of manufacture. Such an indiscriminate creation of exclusive privileges tends rather to obstruct than to stimulate invention. It creates a class of speculative schemers who make it their business to watch the advancing wave of improvement, and gather its foam in the form of patented monopolies which enable them to lay a heavy tax upon the industry of the country without contributing anything to the real advancement of the arts. It embarrasses the honest pursuit of business with fears and apprehensions of concealed liens and unknown liabilities to lawsuits and vexatious accountings for profits made in good faith."

Objective and Subjective Tests

Decisions of the courts and the patent office may be divided into two divergent schools of thought with reference to the testing of invention. One school adheres to the doctrine that invention shall be determined *objectively* by the nature of the contribution to the advancement in the art. The other school advocates that invention shall be determined *subjectively* by the nature of the process by which the invention may have been accomplished. The *objective* test and *subjective* test may be explained with reference to the devices shown in *Figs.* 2, 3 and 4. *Fig.* 2 illustrates the well-known Bendix drive for an automobile self-starter employing an automatically meshing and demeshing pinion equipped with a flattened spring. The principal feature of the drive is the *flattened* spring, a claim covering which reads as follows:

> "For use in transmission mechanism in engine starting apparatus, a spring cooperating with such mechanism and forming a yielding driving connection therein in the line of transmission of power, said spring being of the coiled type and having its coils flattened in a direction at right angles to the axis of the coil."

In a suit for patent infringement, the question arose as to whether the employment of a flattened spring was invention. It is recognized that Bendix did not invent the flattened spring. The defendant offered in evidence many prior patents showing that round, square and flattened springs were old. Of the many prior art patents, the de-

vices shown in *Figs.* 3 and 4 are representative. *Fig.* 3 illustrates a flattened spring in a door check and *Fig.* 4 shows a round spring in one of Bendix's earlier patents. The expert witnesses called on behalf of the defendant stated:

> "Mechanically the only structural change from the starter of the earlier Bendix device (*Fig.* 4), to the starter of the patent in suit (*Fig.* 2) is the substitution of spring 7 of the latter, made out of flat wire, for spring 5 of the former, made out of round wire, and the change is merely good engineering.
>
> Further, both forms of coiled springs are old and well-known tools of the art, interchangeable in general use, to be selected for particular uses according to their known characteristics and special fitness for that use."

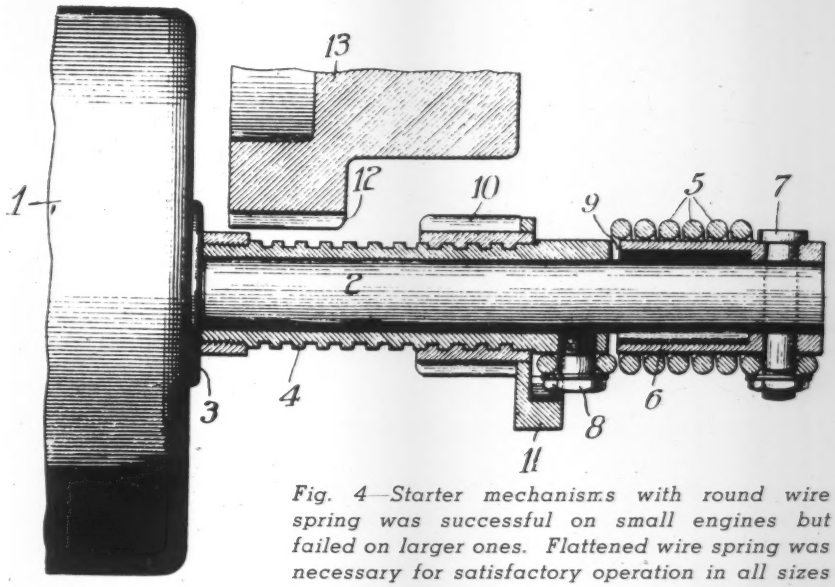


Fig. 4—Starter mechanisms with round wire spring was successful on small engines but failed on larger ones. Flattened wire spring was necessary for satisfactory operation in all sizes

Inasmuch as the Bendix flattened spring was not the first flattened spring, it may be argued *subjectively* that the employment of such a spring in the self-starter was not invention.

It will be seen that the subjective test of determining invention may be characterized as a process of dissecting the device in question into its component parts and then seeking to show that the device may have been conceived or accomplished by selecting substantially the same equivalent component parts from one or more prior art patents, so that from the standpoint of identity of structure, the device in question comprises nothing more than the combined assembly of the selected component parts.

The objective test is not concerned so much with the identity of subject matter which may be found in prior art patents but seeks to determine whether or not the device in question contributed to the advancement of the art. When the objective test is applied and the steps which led up to the use of the flat spring in the Bendix drive are followed, it is noted that the original self-starter produced by Bendix had no yielding driving connection or spring between the starting motor and the pinion which meshed with the flywheel gear. This construction was found to be commercially impractical due to the tremendous mechanical shocks and strains incident to transmission of the required torque.

Round Spring Had Limited Success

To solve the problem of shock Bendix next conceived the use of a spring interposed between the starter and the pinion. The round-wire spring, *Fig.* 4, worked satisfactorily on light and relatively small engines but failed on large engines as the spring would become distorted and finally break. It was also found that a device embodying a friction clutch lacked the capacity to perform properly, particularly with reference to the function of the automatic meshing and demeshing of the pinion. Great efforts were made to render the clutch principle successful until Bendix introduced a spring which was square in cross-section. The square spring developed sufficient torque but did not solve the difficulty with respect to the end-to-end binding of the pinion against the flywheel gear. About a month later, Bendix solved the problem by the improvement of the flattened spring.

It is noted that the flattened spring contributed to the advancement of the art in that the round and square springs could not be made to work successfully for both light and heavy engines. The judge passing upon the question of invention applied the objective test and pointed out that he was convinced that, however simple the change, invention was involved because the device with the flattened spring had been promoted from the field of limited utility of the round spring drive to one of universal utility. The patent accordingly was held valid and infringed.

Objective Test Recommended

Since the purpose of the patent system is to promote the progress of science and to encourage the stimulation of inventions of a worthwhile nature, it appears that this may be best brought about by adopting a standard of invention in harmony with the objective test rather than in conformity with the subjective test. The National Patent Planning Commission in rendering its report makes a recommendation which reads as follows:

> "The Commission therefore recommends the enactment of a declaration of policy that patentability shall be determined objectively by the nature of the contribution to the advancement of the art, and not subjectively by the nature of the process by which the invention may have been accomplished."

Not infrequently an engineer modifies a machine by substituting new material for old material, changing the size or degree of the parts, adding or omitting parts of the machine, changing the form or shape of the machine, changing the form or shape or proportions of the parts, changing the location of the parts, etc. When such changes are made, they should be examined to determine whether or not they contribute to the advancement of the art. As outlined by the objective test in making the examination, it is important that one seek the new function or result brought about by the change.

An example of how to look for the new function may

be found with reference to the rubber tire in *Fig.* 1, which is held upon the rim by means of two wires running through it. Prior to this invention it was considered essential and important that the tire be cemented or anchored to the rim so that the tire could not creep. The absence of cement is the vital characteristic of the invention since the tire is permitted to creep in its channel, thereby producing a radically new and useful result of a patentable nature.

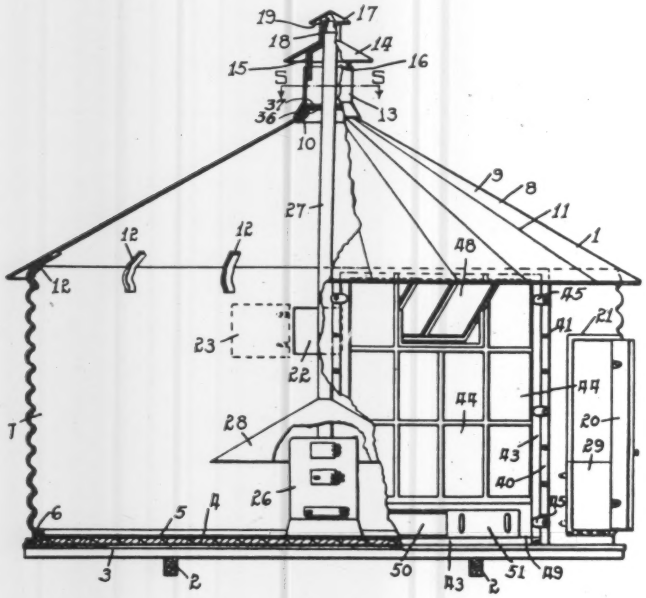


Fig. 5—Use of sheet metal in place of wood for outer walls of chicken brooder was held to be patentable because better radiation characteristics improved the effectiveness of the brooder

Objective Test Is Best Criterion

Another example of how a simple change amounted to invention as viewed from the objective test is found in the replacement by thin sheet metal of wood for the outer wall of a chicken brooder, shown in *Fig.* 5. The new function which the metal produced over wood is shown in the judges' decision which appears in part as follows:

> "In the patent both method and structural claims depend, very largely, for utility and patentability upon the taking of thin sheet metal for the outer walls of a chicken brooder, to utilize the extra radiating power of such material over any other material, especially wood.
>
> "One advantage claimed for the chicken brooder which seemed fantastic when first outlined at the hearing was that the chicks were so affected by the repulsion of the cold walls of the metal sides as to instinctively seek a position a short distance away therefrom where there was claimed to be a circumferential zone of temperature suitable for their comfort and that therefore in connection with the circular form of the structure the fatal huddling of the chicks when uncomfortable was prevented."

When designing new machines or making modifications, designers will do well to keep before them the objective test now recommended by the Patent Planning Commission, so that worthwhile contributions may not be overlooked.

Suggests Development of Postwar Plans

By Paul G. Hoffman
President, The Studebaker Corp.

IT IS MY studied opinion that shortly after peace comes America will have to attain peacetime production and employment levels which, three years ago, would have seemed fantastic. Failure to do so would put free society in jeopardy.

A high level of employment must be attained quickly, because too much unemployment for too long is a direct invitation to dictatorship. Today there is general agreement on that point. Perhaps what has not been so clearly recognized is the further point that, if government provides too many jobs for too long, the result will be exactly the same so far as the effect on the maintenance of free society is concerned. Pressures created by either too much unemployment, or by too much government employment, may vary somewhat but lead to the same result. Too much unemployment, too much government employment for too long—either or both spell death to a free society.

While we must keep constantly in mind the need for jobs, high-level employment by itself is not enough. High-level employment alone could be attained easily if, in striving for that goal, we disregarded completely the reasons for its attainment—a high standard of living and the maintenance of our free society. To avoid hazards in the attainment of those objectives we must accept as our primary objective high-level production in private industry. Let us never forget that there just is no substitute for work.

In my approach to this problem of postwar employment

in private industry you will note I use the term high-level employment and not *full* employment. Full employment is a nice-sounding phrase, but exactly what does it mean? Does it mean a job for every man and woman, for every husband and wife in America? If so, what kind of a job? Does it mean a job working 40 hours a week, with sufficient pay to provide a satisfactory standard of living or a job working 12 hours a week with just enough pay to provide a bare existence? Does it mean a job created by giving up steam shovels and going back to hand shovels or, for that matter, teaspoons? Without the answer to those questions, the term full employment is utterly meaningless and misleading.

The question of creating jobs as a result of technological advancement deserves special emphasis. Despite seeming acceptance of the premise that jobs are created by selling goods for less, in times of stress we are apt to forget it. If there are any questions in your mind in that regard they should be answered by the little-publicized recent report to the National Bureau of Economic Research entitled "Employment in Manufacturing, 1899-1939—An Analysis of Its Relation to the Volume of Production." In this report the Bureau points out that the industries with particularly large increases in both employment and output between 1899 and 1939 were in general those in which exceptionally large declines occurred in employment per unit of product. It mentions the automobile industry as having cut jobs per unit most sharply in that period and yet registering the largest gains in employees and output. The lumber industry increased its employment per unit of product and suffered a sharp reduction both in total employment and total output. In the light of this report it should be clear why we decided to make high-level production our primary objective.

"INDIVIDUAL enterprises must start now to plan their own postwar activities" says Paul G. Hoffman, president of The Studebaker Corp. and chairman of the Committee for Economic Development. In this abstract of an address delivered at the twenty-seventh annual meeting of the National Industrial Conference Board in New York, Mr. Hoffman discusses postwar employment problems and how his committee is set up to aid in facilitating high-level production

How can private industry achieve the high-level production necessary to make its maximum contribution to the attainment of what we consider a satisfactory level of employment?

I should like to answer that question by telling you that in the consideration of this problem the men associated with me in the Committee for Economic Development have come to two main conclusions:

1. Individual enterprises must start *now* to plan their own postwar products and postwar markets.
2. The environment in the postwar period must be favorable to the expansion of enterprise.

Now I should like to tell you how the C.E.D. proposes to make its contribution. First, let me mention that I have no confidence whatever in the ability of any agency—public or private—to make over-all plans for our economic system, or for our business program. However, I do have the highest confidence in the ability of individual businessmen to plan for the future of their own businesses. In my opinion the initiative and resourcefulness of the individual enterprisers in this country constitute one of our greatest national resources. The problem is properly to develop this great resource, to stimulate hard thinking on the part of these entrepreneurs.

The job of stimulating, encouraging, and helping these individual enterprisers make their own postwar plans is the responsibility of our field development division. This division is headed by a committee of twelve regional chairmen, one for each of the federal reserve districts. These regional chairmen are appointing district chairmen who are responsible for the organization of local or community committees. These local committees are completely autonomous. Their job is to mobilize the brains in their communities so that the communities, themselves, can solve their own postwar problems. The only thing we ask them to do is to pass on to the national organization any ideas they may develop so that we may make them available to other community committees.

We are not overly concerned about planning by the very large employers, some five hundred of the three million business establishments in this country. They have the resources and also the technical ability to do a first-class job of their own. It is the smaller businesses—the approximately two million actual employers and the one million self-employers—which need both encouragement and help in getting their programs under way. In the aggregate these work-givers provide many millions of jobs. They are the grass roots from which our economy grows. They are the shock troops we must use to win our objectives. They must start planning *now*, and they must plan *boldly*, and they must plan *intelligently*.

Our committee is concerned directly only with the domestic economy. But the international economic climate which prevails after the war will have an important bearing on employment in private industry in America. Because of the great strides being made in the field of aeronautics, all natural boundaries are disappearing rapidly. America of the postwar period will hold an entirely different position in this world of ours than the America of the '30s. By the time this war ends every country in the world will be our close neighbor. In the light of this geographical revolution, does not isolationism become a thing of the past? Are not those of us who persist in thinking as isolationists headed down a blind alley?

It Can Be Done!

Given a favorable economic climate, given the courage to plan boldly, and given the will to do the job, we have every chance of meeting the challenge of postwar production and employment successfully—because the market is going to be there in a big way.

Attacking this task of insuring high-level production and employment gives us as businessmen an inspiring chance, by *bold* action based on *bold* planning, to help build a better new world. Certainly none of us wants to go back to the prewar world of the '20s or the '30s.

Plastics Help Conser

By Clem G. Trimbach

Research Laboratory
Curtiss-Wright Corp.

SUBSTITUTION of new materials for strategic resources has been an important consideration in all foreign countries since before the war started in 1939. Except for aluminum and magnesium, however, the United States experienced little of the effect of material shortages until actual entry into the war and the launching of our enormous war production program. As the months of 1942 passed, the importance of material substitution became increasingly apparent. Today it is one of the most serious problems which industry has to face. The fact that some industries have been given priorities on certain materials does not lessen their duty to work in concert with all other industries in eliminating unnecessary applications of strategic resources.

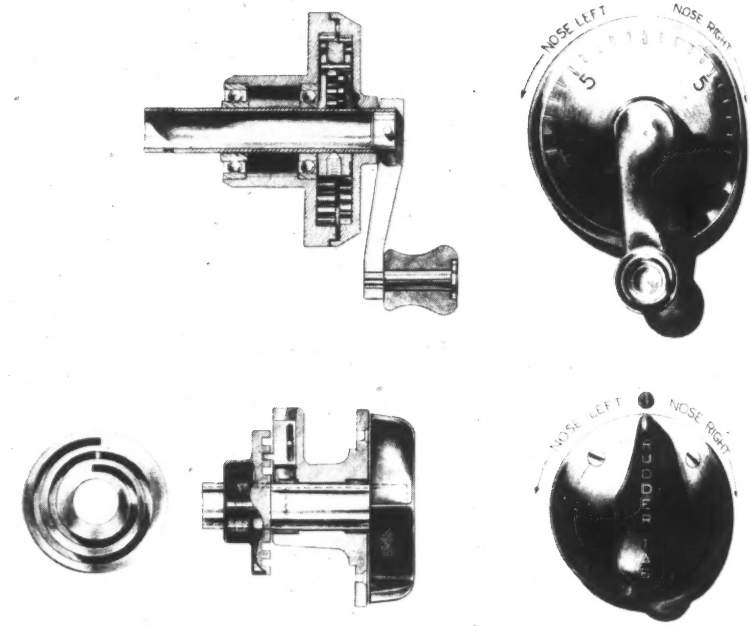


Fig. 1—Above—Made entirely of metal, the complex crank assembly (top) was replaced by the simpler plastic knob assembly (bottom)

With its high rating in aluminum allocations, the aircraft industry has a definite obligation in the war production program to find and adopt shortage-free materials to replace those of greater scarcity. Certain applications of the light metals must necessarily continue, but many structural, as well as nonstructural parts already have been successfully redesigned for material substitution. From its work in this direction, the industry as a whole has learned an important lesson: Aluminum for many applications, can be replaced by other materials with equal or better performance, and at reduced cost and weight.

Availability Picture Constantly Changing

To the question of what materials are strategic, the answer changes almost daily as new shortages appear. The problem thus becomes more complex as substitutions of a few months ago return for further consideration because of critical shortages in what was then a shortage-free material. Directives call attention to the scarcity of the material and everyone turns to the material generally thought to be next best. The result is that the substitute material cannot sustain the huge increase in demand, and corrective steps have to be taken. Naturally it would be helpful if manufacturers could be kept constantly informed as to where the various materials stand with regard to supply versus demand. However, the demands of thousands of war manufacturers, producing millions of war products, present a changing picture so complicated that it is impossible to foresee all materials crises. Therefore the solution to the problem rests, in most cases, on the shoulders of trade associations or on the individual manufacturers themselves.

At the Curtiss-Wright Corp. a comprehensive long-range program was established over a year ago to study material replacement problems. Certain general requirements for substitute materials were established at the beginning. The substitution should be as light as, or lighter than, the part to be replaced. Performance under extreme temperature conditions should meet specifications, and the other necessary physical characteristics of the parts

should be comparable. Costs should be the same, or less.

Not long after this program was started it was realized that merely substituting one material for another in the same design was not achieving the maximum improvement. Many of the parts which came under consideration were found to be of unnecessarily complicated design. Through design simplification it was found that costs could be reduced still further by eliminating expensive manufacturing processes on a multiplicity of parts forming a single assembly. The work of the material substitution planner thus was expanded to cover not only the choice of the proper substitute material, but also the advisability of redesign.

An example of this type of material-design change occurred in the case of the rudder tab control shown in *Fig.* 1, which originally was made of metal. The complexity of the mechanism suggested the possibility of simplifying the mechanical action. A check with pilots who had used this control during flight revealed the crank to be actually undesirable. It was therefore replaced by a knob, made of plastic. The graduations on the dial filled no useful purpose according to the operating personnel, so they were ruled out. This not only eliminated the graduated dial but also the internal gears and the gear housing. The required action of the knob was a complete revolution up to the stop in each direction. This was accomplished by means of a spiralling key-slot disk made of plastic, operating in conjunction with a sliding key. Finally, the main housing was also redesigned to be made of plastic, the ball bearings being replaced by molded-in plain metal bearings. The new assembly of three main parts is easily molded, requires only a few simple machining operations, and is simple to assemble. This replaced a unit of fifteen individually machined parts. One of the chief advantages of such a simplified design is that the entire unit can be purchased from one vendor, ready for installation without further processing.

Bag-Molding Technique Utilized

Among the first items to which material substitution was successfully applied, was the map and data case shown in *Fig.* 2. The original case, shown at the left of the illustration, was formed of duralumin with riveted hinges and edges. Its assembly was quite complex. The first substitution for metal was made with sections of high-pressure phenolic paper laminates, riveted at the joining edges to cadmium-plated steel hardware as shown at the center of *Fig.* 2. Cost was reduced, but overall weight reduction was slight. However, the important point is that aluminum was eliminated. The case was successfully used in production aircraft for many months, but recently was again under consideration. It was then decided to replace it with a new type made possible by the developing technique of low-pressure bag molding. This latest case, shown at right of *Fig.* 2, is formed from a single built-up sheet of low-pressure bootleg duck phenolic laminate. The cover and flap, with tough, thoroughly tested cloth hinges, is made as a separate piece using the same material. Adoption of this simplified case has further decreased costs, and a substantial weight saving has been accomplished. Use of metal has been completely eliminated except for the catch and a few grommets.

Another application of low-pressure phenolic laminates is the aileron hinge fairing shown in *Fig.* 3. Formerly it was made of two pressed duralumin sheets welded together to the necessary aerodynamic shape. The new

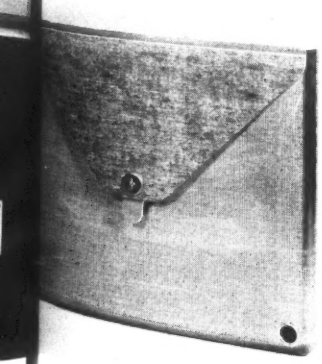


Fig. 2—Left—Center case, made of riveted phenolic paper laminate, was first redesign of all-metal case at extreme left. Latest redesign is shown at right

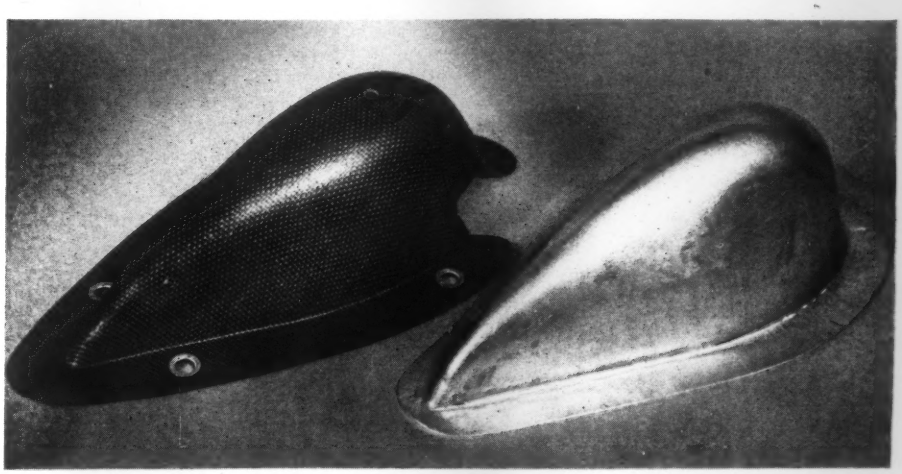


Fig. 3 — Substituting the low-pressure-formed phenolic laminate unit shown at right, for metal aileron hinge fairing illustrated at extreme right, reduced the weight, cost and manhours required for fabrication

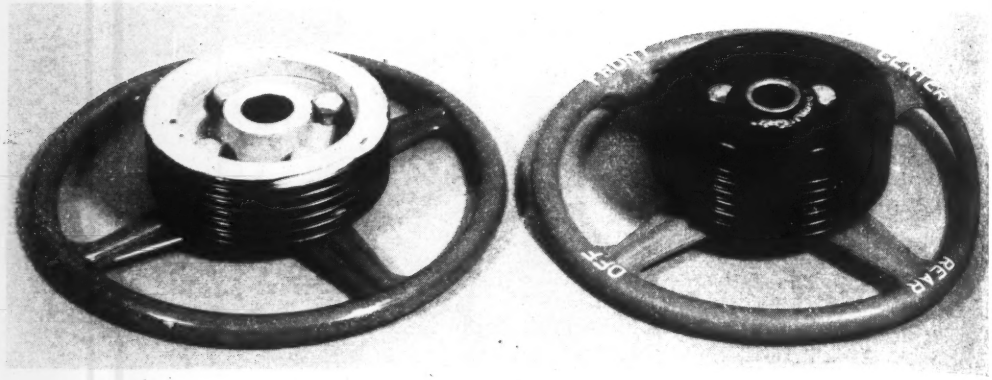


Fig. 4—Plastic wheel and drum unit at extreme right dispensed with all-metal assembly shown adjacent to it. Substitution cut weight and cost by half

fairing reduces weight and cost, eliminates the use of metal, reduces man hours required for forming, and provides a smooth hinge cover which is just as effective as the former metal part.

Originally, the fuel cock selector wheel and drum assembly pictured in *Fig.* 4 was made of two aluminum parts as shown at the left of the picture. In determining suitable material substitutes for the parts, the usual weight and performance questions were involved as well as the possibility of extremely rough handling in emergency action. Requirements were satisfied by the use of two different materials. A high-impact phenolic molding powder was chosen for the drum, compression molded at 4000 pounds per square inch. This material, with macerated rag filler, cut weight and cost to one-half the former, saved the critical aluminum formerly used, and eliminated the machining operations necessary to produce the early part from duralumin bar stock. The wheel, formerly an aluminum casting, was changed to cellulose acetate butyrate. In place of the previously required steps in machining, heat treating, anodizing, painting and then filling in of the characters, the plastic part requires only the molding material with the required color (in this case red), in addition to the filling-in of the characters. The color of the plastic part is permanent, whereas the metal part required repainting with enamel after extended service. Weight was reduced to less than one-half and cost was cut by approximately the same amount.

An example of replacing a plastic with another plastic is shown in the ammunition box rollers of *Fig.* 5. The original roller was made of laminated phenolic and required machining after molding. It was replaced by a cellulose acetate injection-molded part, which comes from the mold ready for use without further processing. The new part costs one-tenth the price of the former and is less than one-third the weight. Further, while the original roller required a shaft pinned in place, the new type roller eliminates the shaft and pin.

In addition to the individual items described above, many other successful substitutes of comparatively nonstrategic materials have helped to reduce by thousands of pounds the strategic materials used in Curtiss-Wright planes. New and more efficient materials are constantly being tested for use in such diverse applications as junction boxes, aileron ribs, ammunition boxes, rollers and other airplane components. Plywood of aircraft grade has itself become a rather scarce material through its successful applications to aircraft structural sections and even to whole planes such as the "Caravan," a transport ship now being produced in quantity at one of the Curtiss-Wright plants.

Full significance of material substitutions in aircraft and thousands of other war machines is only now being appreciated. No one can claim to have an acquaintance with all present changes, to say nothing of trying to predict the extent of future innovations. However, it can safely be stated that in a great many cases, redesigns which have been forced by materials shortages are proving simpler and better than former designs. Further, the true potentialities of nonstrategic materials as revealed through forced substitution today will result in their permanent adoption for many applications, heretofore foreign to them, during the postwar period.

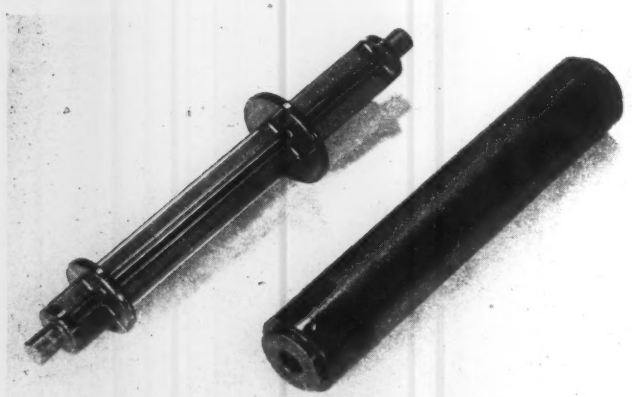


Fig. 5—Ammunition box roller at right required machining and assembly with shaft (not shown). It was replaced by one-piece injection-molded part shown at left

SIMULATING the racket and recoil vibrations of a real antiaircraft weapon, a machine gun which uses plastic pellets and compressed air is now being used to train our soldiers. Identical to the 50-caliber Browning in size, appearance and rate of fire, this specially developed General Electric gun is extremely economical to operate, its pellets costing but one cent each. Used by the trainee to fire at miniature buildings, tanks, airplanes, etc., the gun's firepower is such as to provide pellet velocity and trajectory which accurately simulate combat conditions within the firing range of the weapon. Trainees learn to "lead" a moving target and to aim by means of the white pellet stream which becomes fluorescent at night in the "black light" of an ultraviolet spotlight attached to the gun.

Designing War Equipment for Accessibility

By Col. E. S. Van Deusen

Ordnance Department
Tank-Automotive Center

OF WIDELY recognized accessibility factors applying generally to mechanical equipment, there are several to which must be ascribed far greater weight in distinctly military circles than is accorded in usual commercial practice. This difference stems directly from the relative importance of operating profits evaluated on a pure dollars and cents basis. The profits of war are difficult, if not impossible, to translate into terms of monetary exchange. Economy of human life becomes the profit motive in military operations. The sole purpose of mechanizing and motorizing our troops in the field is for the physical destruction of enemy forces and their will to fight in the least possible time and at the least possible cost of our own flesh and blood.

Factors involved in accessibility go far beyond a conventional placement of the components in an assembly. The physical relationship and placement of a part or component with respect to its mating units and surrounding parts is of prime importance, determining, of course, the ease with which it can be inspected and handled. Clearances for the hands, and for the removal and return to their places of parts which require removal in servicing operations, are mandatory. Provisions for visual observation of adjustment markings, and finger or tool clearances which will simplify indicated adjustments also are "must" items.

Any unit which requires the use of tools in the removal of covers

Fig. 1—Above—Service adjustments necessary to keep tanks in fighting trim often must be performed without benefit of heated shops and concrete floors

Fig. 2 — Below — Maintenance and repair facilities such as this modern commercial shop offers cannot be provided for military vehicles in combat zones

*Abstract of a paper presented at the recent S.A.E. War Materiel meeting in Detroit.

or interfering parts, in order to make it accessible for adjustment or servicing, cannot logically be considered satisfactorily accessible. Also, requirements of specially designed tools in the servicing, particularly the adjustment and lubrication, of a unit detracts materially from its adaptability to military usage. Special tools are the bane of military automotive maintenance. The ideal vehicle design from this viewpoint is one which can be disassembled, assembled, serviced, and adjusted completely from bumper to bumper and from the ground to the top of the body by the use of human fingers, strength and intelligence alone. Since this is obviously impractical, the goal for military purposes should be service ease requiring only a screwdriver, pliers and possibly a single adjustable end wrench. Say what you will of the much advertised and admittedly tremendous technological advance of the automotive industry over the past quarter-century, modern equipment does not compare favorably with the equipment of World War I with respect to accessibility of critical components and accessories.

The time element is properly divided into two phases—hours and minutes required for actual repair and adjustment, and time interval elapsing between required and

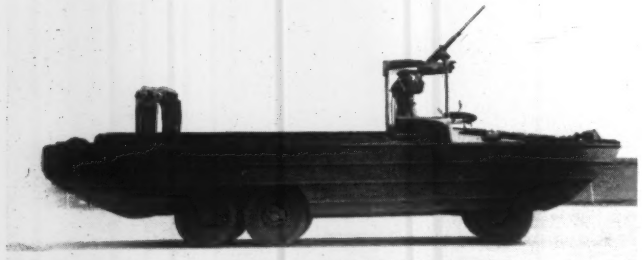


Fig. 3—Amphibian truck is a special-purpose vehicle which presents unusually difficult problems in designing for accessibility

scheduled servicing and maintenance operations. Time involved in removal, replacement and servicing of a unit or part is of particular importance in any military operation. Modern combat is a fast-moving situation. Any factor relating to equipment which ties up the mechanical aids to swift victory for any appreciable period of time is as deadly an enemy as the opponent himself. Under air observation and attack it is imperative that forward echelons keep on the move to prevent the destruction of equipment as a result of the mere static location of forward installations which may become known to the enemy. In the British advance from El Alamein, for example, it was necessary to limit the stay of advance shop groups to not more than 24 hours in any one location. A longer time invited destruction of the base. Naturally the accessibility of parts requiring repair was of extreme importance in determining how many vehicles could be repaired and returned to combat by forward elements at each stopping point.

Equally important is the time interval elapsing between indicated servicing and lubrication operations, as it may determine the extent to which equipment is deadlined out of service. From a design standpoint, any construction which lengthens the period between such servicing operations is highly desirable, provided the wear factor does not overcompensate by requiring more frequent first and second echelon attention.

Improved mass production methods introduced by the automotive industry in late years have not always served the cause of accessibility. Availability of new machine processes, the use of stampings instead of forgings or castings, the wide application of welding, and the integral types of construction often applied to units subjected to wear, while serving well the purpose of economical mass production and lowered unit costs, in many cases have resulted in an end product which leaves much to be desired in simple maintenance operations by the field soldier who seldom has ready access to the highly specialized repair and maintenance equipment and tools available in centers of heavy population or, in the military equivalent, base shops. This broaches the matter of military *versus* commercial maintenance problems.

Hazards of Enemy Action

Mechanized equipment has not yet been perfected to the point where it will operate indefinitely without maintenance, and even if such perfection and wear-proof qualities were within our grasp, as long as the enemy can inflict damage on that equipment, repair and maintenance must be provided. Components which may, in nonmilitary service, be expected to serve admirably with a large factor of safety through the entire life span of the vehicle may, in combat service, require unit replacement because an enemy sniper has put a rifle bullet or large projectile through it. In these days of espionage and counter espionage, he may have been instructed to sight his telescope on that particular unit because his superiors know, from the examination of captured material, that the part cannot be easily and expeditiously repaired or replaced. In order to accomplish maintenance, the crews must be able to get at the parts which require attention. It is, therefore, elementary that the better the accessibility provided to all components, the more easily can the military effectiveness of the equipment be revitalized.

Maintenance Problem Is Acute

It has been stated recently by several ranking officers that our problems with mechanized equipment are, to a large extent, on the way to satisfactory solution insofar as the production phase of the war program is concerned. But as equipment flows into active combat and training service the problems of keeping it in operating condition increase, and the emphasis must pass to maintenance and repair activities, not overlooking the supply problems relative to providing the needed parts where and when needed. The phrase "when needed" means just that, without any waiting to have the part shipped from the factory. Also, and this is one of the principal points, when that part is on hand any delay incident to putting it to work in place of the damaged part cannot be tolerated, because there never will be enough transport available where it is needed until our victory is won.

Any action which reduces the percentage of technical personnel required and permits another rifleman, machine gunner, or bazooka bearer to bring his firepower to bear

on the enemy is an essential objective. If nonaccessibility of a certain part of a given vehicle requires any more than an absolute minimum of time for adjustment, replacement or servicing, the result is an unnecessary waste of manpower. A routine 1000-mile inspection, required for all military vehicles, consumes an average of 12 man-hours. The normal assignment of company mechanics in type organizations averages one mechanic to each 15 trucks. He is responsible for making the 1000-mile inspection of each vehicle under his charge at least once each month. He also assists the battalion or regimental mechanics in the 6000-mile inspections given at least once each 6 months, at a normal rate of three or four a month. His other duties include the inspection of drivers and assisting them in their daily inspections, trouble-shooting and emergency repair, and adjustments as necessary. He does not have any spare time to waste in coaxing a hidden or hard-to-get-at part out into the open so it can be lubricated or adjusted, and he doesn't have more than the minimum tools with which to do his work. Space in the trucks of an operating company must be used for carrying ammunition, subsistence and other supplies, rather than for an elaborate set of tool equipment. His job cannot be accomplished unless he can see, feel and manipulate the parts requiring attention. It also must be clearly remembered that parts, lubrication fittings, etc., which are not readily accessible invite neglect or insufficient and even incorrect lubrication, a postponement or improper adjustment, all this despite the preparation of the most complete lubrication charts and adjustments instructions imaginable. Inaccessibility increases not only the man-hours required for proper maintenance but also the nervous and physical strain on mechanics, often when the tension under field conditions is at the breaking point without the addition of annoying delays which the designer could have prevented by a slight change in the inception of his brainchild.

Designing for "Cannibalization"

Another angle in the military pattern which is not as critical in the commercial picture is the use of a procedure which we call "cannibalization". Unit mortality in military service follows no fixed or predictable cycle and the supply system, especially in overseas theaters, will always be strained to the limit. The ability to make one serviceable vehicle out of two, three or even a half-dozen cripples may give the theater commander just that narrow margin of superiority which he needs to win his objective. Those who have read of the feats performed in this respect by the gallant defenders of Wake Island, Major Devereaux and his hard-bitten marines and airmen, can appreciate the importance of designing for easy "cannibalization".

Commercial operating units, due to the competitive factors involved, must pay attention to details of eye-appeal and style, protection of load, comfort of driver, and many other factors which do not apply to the military use of mechanized equipment. Military equipment is, and must be, essentially functional in all respects. The best examples of this principle are our tanks and combat vehicles, which have been designed and developed for the single purpose of battle efficiency. However, our procurement policy since 1933 has been based on the principle of using commercially produced vehicle designs with the minimum modifications required to meet specific military purposes. Consequently the problem of improving the accessibility of parts in our military vehicles was not as simple as it might have been.

It is not the purpose of this article to reflect upon the merit of commercial equipment, as manufactured for commercial use, from the standpoint of accessibility or any other particular feature. In general, all commercial designs have their good points and also their respective questionable details. This is really a good condition. It is the basis of free enterprise and competition without which advancement in technique and processes resulting in the availability of improved vehicles at lower price levels than otherwise would be available, would have been unattainable. These advances have included major changes, which make the modern vehicle vastly more complicated than those of the era of World War I, such as the general adoption of electric starting and lighting, brakes on all wheels, six and eight-cylinder engines, oil, air and fuel filtration, power brakes, engine temperature regulation, and multispeed axles. All of these desirable improvements have, nevertheless, made accessibility an objective more difficult to attain.

Certain designs are especially bad offenders against the cause of accessibility. Many of the points of inaccessibility which have been disclosed arise from the process by which the vehicles are designed and built. The engine designer may have been exceedingly diligent with respect to the accessibility of parts so far as the engine alone is concerned, and it is probable that, mounted in a stand, its parts and adjustment points are easy to get at. When installed in a chassis, however, unforeseen interference with other chassis units or parts may occur which make even the simplest repair or adjustment operation all but impossible without removing the engine from the chassis. While this may be a comparatively simple operation in itself, complications often arise in accomplishing it after the cab, radiator and fenders have been assembled to the bare chassis. To get at the engine or for unit replacement, the reverse of the assembly process may be required. In one case simple replacement of the fan belt has necessitated a half-hour's wastage of labor in disassembly and reassembly, and in another the steering gear could not be

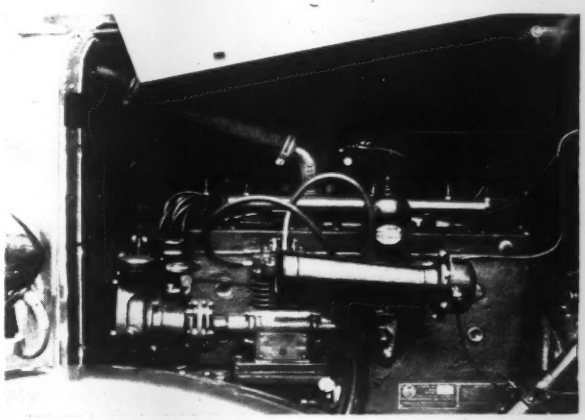


Fig. 4—An example of good design for accessibility, this truck engine requires minimum removal of parts in making vital repairs

removed unless the engine was first taken out.

Some examples of conditions which called for corrective action will be cited. One involved the transfer case of one of our larger trucks. A bolted support was used so that mounting brackets were permanently attached to the frame, the transverse supporting members, riveted to the transfer case, being bolted thereto. In a stripped chassis the unit could be readily removed or replaced, but when the cab and body were installed these bolted connections were no longer accessible. Removal required that the rivets be burned out and replacement required reriveting or reaming of the holes and the substitution of bolts. Revision of the design now provides bolts in the original assembly.

Some of these situations are the results of slight oversights—others plain, undiluted blunders. The majority of them either have been or are in the progress of being corrected.

It should be appreciated that tank design sometimes must submerge the consideration of ideal accessibility to those of ammunition storage, fuel capacity, gun position, low silhouette, etc., but every time this is permitted we run into the trouble of neglect, mentioned before. For the cubage involved, the interior of a tank is more congested with machinery, equipment, and battle supplies than anything else I can recall except a submarine. Even at the present state of development, rapid and thorough inspection and lubrication of some models require the services of a superman contortionist adept in sleight-of-hand and acrobatics.

Fig. 5—Accessibility and use of standard tools aid in the servicing of vulnerable parts such as tires and wheels

Items of light maintenance such as the replacement of oil-filter cartridges have required considerable corrective action to reduce the time consumed in such a simple operation. Service adjustment of electrical accessories has been made easier in a number of cases by relocation, in both tanks and transport vehicles. Radio shielding has been greatly simplified and no longer requires the use of a complicated system of cable and unit armoring. The overhaul of the clutch on one early model of tank, a simple job in itself, could not be accomplished without the disassembly of the drive train and removal of the engine, and the whole operation consumed nearly three days time. Needless to say, this has long since been corrected. In another model, a change in the oil tank design not only eliminated a lot of exposed piping, thus removing a potential source of damage, but also provided room in the engine compartment facilitating routine service operations and making the power plant much easier to remove for heavy repair or replacement. Sheet metal shields, ducts, etc., have been redesigned in many tank applications, permitting ready removal to provide access to components previously difficult to reach. It is remarkable that some of the engines in early tanks did not suffer from claustrophobia. Who knows but that many of the failures which were attributed to commonplace engine ailments were not in fact due to this very phobia!

The provision of hinged instead of bolted inspection covers has materially improved accessibility of later tanks over the early production models. Quickly detachable electrical, fuel and other connections, coupled with means for easily and quickly exposing the power plant and train, as on a shop stand in certain of our later models, and the relocation of lubrication fittings in easily reached places, indicate the extent to which close attention is being given by Ordnance Department tank engineers to the problems of accessibility. The adoption of construction which permits the unit replacement of certain components almost as quickly and easily as a fuse or an incandescent lamp, is a step forward and is not entirely outside the bounds of possibility for application to powerplants.

Combatting Mud

One interesting change from conventional commercial truck design practice has resulted from the battle with old man mud. In field operation over soft muddy terrain the brake drums become clogged with mud, requiring early cleaning to prevent serious damage to the wheel brake system. The conventional design required disassembly of the hubs and exposure of the wheel bearings, a lengthy operation which also invited contamination of bearing surfaces. Designs now in production provide removable brake drums on some vehicles, furnishing a solution to the still controversial subject of fully enclosed *versus* open brake mechanisms.

In the last analysis, relative accessibility is measured in units of time by our troops in the field—and in the theater of operations, time is measured in flesh and blood. Thus, a physical relationship of units and assemblies such as may enable maximum, unhindered, manual adjustment on the one hand, and minimum special tool work on the other, is to be classed as nothing less than a military objective in itself.

Finally, in the year and a half since Pearl Harbor, indications from the field raise a serious question—"Have we or have we not considered accessibility, as an adjunct to military effectiveness, in its proper relation to the design picture as a whole?" Frankly, we still have a distance to go! Admittedly, natural laws and physical limitations simply do not permit designers to do everything they would like to do. We all know, however, that engineering is an eternal compromise. May I propose that we compromise just a bit more in favor of accessibility?

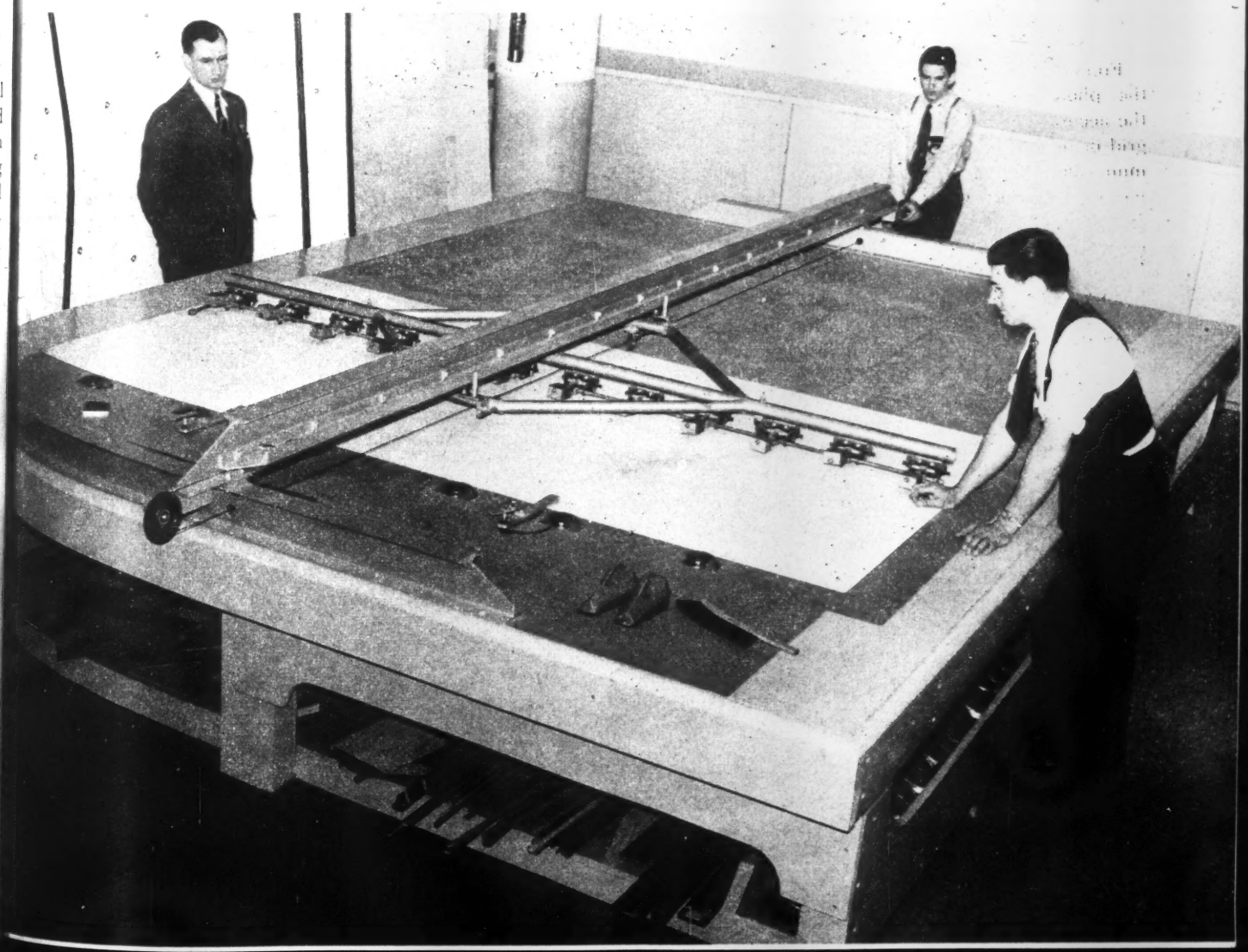
Gang Scriber Facilitates Accurate Drafting

By A. H. Allen

AS COMBAT and transport aircraft become increasingly larger, so are magnified the problems incident to their design and the transfer of design to shop production. Preparation of full-scale drawings or master layouts of parts and components goes far beyond ordinary drafting-room practice and calls for considerab.e ingenuity, both in the interest of maintaining accuracy of detail and in handling layouts which may become as much as 20 x 40 feet in size.

Sometimes called lofting because of the similarity with technique used in shipbuilding where full-scale layouts are drawn in ship lofts, aircraft practice has been refined considerably since its inception and metal has been substituted for paper in master layouts. First aluminum sheets were tried, then discarded in favor of .038-inch stretcher-leveled cold-rolled steel because of its greater

Fig. 1—Specially designed grid machine scribes twelve parallel lines simultaneously on a painted steel sheet for master layouts. Improved accuracy and greater speed are important advantages over former hand-scribing method of laying out a grid



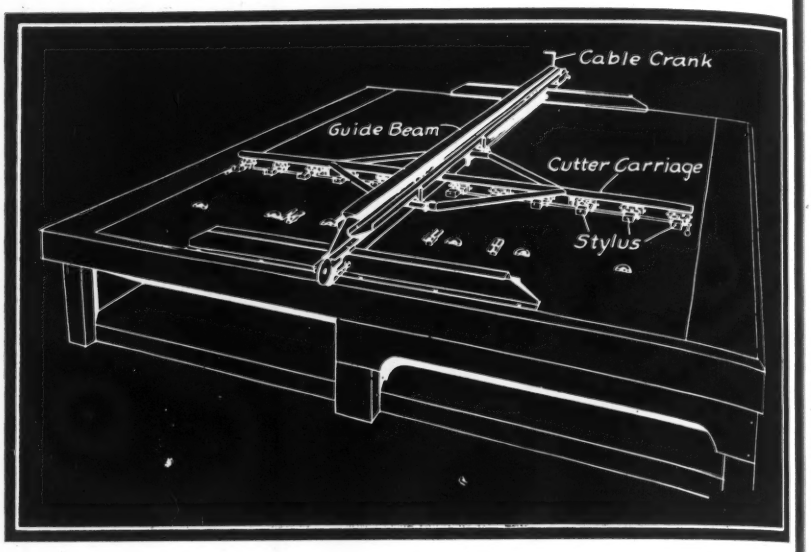


Fig. 2—Schematic arrangement of grid machine. Crank at far end operates cable which draws scriber boom across he table, drawing twelve lines at one time

rigidity and dimensional stability under temperature change.

Master layout unit of the engineering division of Boeing Aircraft Co., Seattle, Wash., follows this general procedure: Steel layout sheets are sprayed with a light green paint known as Preparakote, five coats to the sheet. Reference grid lines are scribed on the sheet 10 inches apart, both vertically and horizontally. Then the drawing of the part is scribed onto the sheet, using the grid lines as reference points, with plastic-bodied scribers having silver solder "markers". Next the layouts are mounted on easels and photographed one-fifth size onto glass negative plates. The negatives are used to project the image full size on sensitized steel templet sheets through the same camera which photographed the master layout. Templets are "developed" and cut into the forms the drawings indicate, after which they become the working templets used in the plants for flat pattern work—shearing, routing and blanking. They are also used for the great number of parts which require bending or forming on hydropresses and brakes.

Accuracy of Lines Is Vital

From the foregoing summary of the principal steps in the phototemplet process, it can be appreciated that the accuracy of the original master layout with its scribed grid or reference lines is of vital importance. Since maximum allowable variation or tolerance in drawings is .01-inch, it becomes essential that the reference lines be perfectly straight and one set truly perpendicular with the other.

Originally, all the reference grid lines were scribed by hand on a layout 40 feet long, using steel scales and straight-edges to mark the lines on the aluminum sheet. It proved difficult to hold a marking instrument steady enough in relation to the straight-edge to make a perfectly straight line, and a check also showed that lines drawn on the portion of the sheet nearest windows were "out" by 1/16-inch the next day as the result of contraction of the sheet. Although it was possible to determine mathematical compensations for the expansion effect, this was a tedious and troublesome procedure. Hence a new method was sought.

Lyle H. Pierce, chief of the master layout unit, eventually worked out a solution to the problem in the form of a grid machine which scribes 12 lines at a time and squares off the layout sheet in a matter of minutes, requiring only two operators. The novel machine, shown in *Figs.* 1 and 2, comprises a table, a cutter carriage, a guide beam and a squaring device. The table is about 3 feet high, approximately 12 x 15 feet in size and covered with a ¼-inch plate of stretcher-leveled steel. It contains an adjustment feature which permits leveling of the unit during construction.

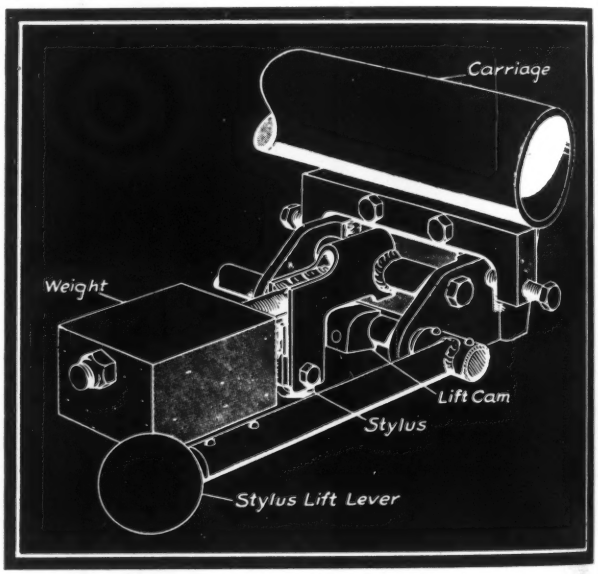


Fig. 3—Detail of hinged scribing bracket with stylus. Position of weight can be varied to change pressure on stylus. Lift lever raises individual markers

Cutter carriage is a welded tubular frame on which are mounted the 12 hinged cutters or scribers, three rubber-tired wheels, four guide bearings, two camshafts and handles, and adjustments for setting the cutters to proper spacing and depth of cut.

Adjustments Are Simple

Cutters are hinged as shown in *Fig.* 3 to permit raising and lowering by means of a cam arrangement, so that the layout sheet can be cleared before and after the lines are scribed. The scribing stylus itself is tipped with cemented tungsten carbide for long wearing qualities. A movable weight is mounted on a threaded arm over the cutter and can be set at any point along the arm to vary the pressure on the cutter which in turn permits different depths or "strengths" of the scribed lines on the green-coated sheet.

The cutter carriage travels over the table top on the

rubber wheels and is guided by bearing rollers in contact with a steel straight-edge as is shown in *Fig.* 4. This in turn is bolted to the lower flange of an I-beam resting on supports at each side of the table. Clearance above the working surface is about 5 inches. The I-beam is stabilized against side deflection by two steel channel sections bolted to the web of the beam.

Double Wrench Adjusts Spacing

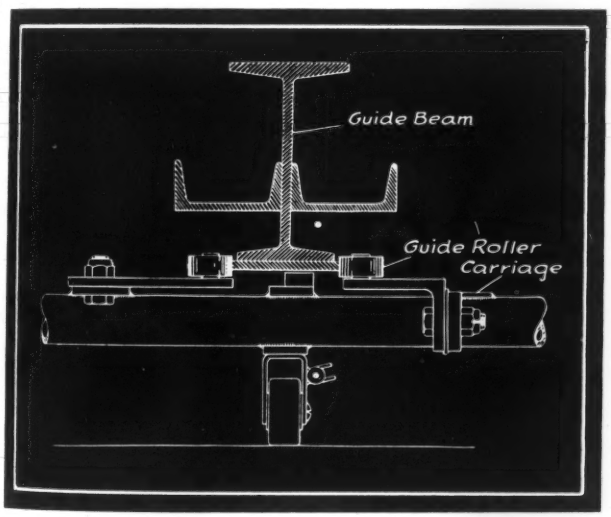
Cutter brackets are located about 10 inches apart along the main carriage tube and can be adjusted to exact 10-inch spacing by means of a special wrench which turns two bolts on the bracket at once. The bolts bear against each side of the hinge bracket and permit .003-inch movement of the cutter when the wrench is rotated through about 20 degrees.

Hardened steel bolts are inserted in bushings at one end of the table for accurate alignment of the layout sheets. These bolts have a countersunk hole located eccentrically in their heads, shaped so that a tram point can be inserted snugly. The holes are adjusted in a straight line perpendicular to the cutter travel and set with a locknut. By scribing the sheets in one direction and rotating them 90 degrees, the reference lines can be set accurately with tram points. This results in accurate perpendicularity of one set of lines with the other. Simple screw clamps rotating over a fulcrum rod and hold-down bolts fasten the layout sheets securely to the table, preventing any movement.

Each endless cable traveling over pulleys at each end of the supporting rail is used to draw the scribing frame across the table and back, being operated by a crank from one side. While the hinged brackets mounting the scribing stylus are interconnected so that all 12 may be raised simultaneously to clear the layout sheet, it is also possible to raise each bracket independently, and also to vary the pressure on each stylus during its travel across the sheet to change its depth of cut.

Often, when drawings are large, it is necessary for draftsmen virtually to lie down while working on the templet. For such cases it is imperative that no part of their clothing cause any scratches on the coated layout sheet. Shoes being the worst offenders the men wear moccasins, as shown in *Fig.* 5, for protection of the work.

Fig. 4—Cross section of I-beam support with channel-section stiffeners and straight-edge along which rollers travel to guide scriber carriage



Composites Used for Larger Layouts

The present Boeing grid machine is limited in the size of layout sheets it can handle to the 12 x 15-foot table. Larger layouts necessarily must be composites made by placing together several of the 12 x 15 sheets and fastening them firmly where the grid lines match. However, a still larger grid machine which will handle 20 x 40-foot sheets is being developed.

An unusual method has been adopted to hold the finished master layout sheets and templet sheets to an easel during the photographic process. The surface of the easel resembles that of an oversize rectangle waffle iron, with hundreds of small holes drilled in it. The steel sheet is placed against this surface, suction applied from the rear and the sheet is held firmly in place. Camera and easel used in the process together weigh over 6 tons and are valued at close to $20,000.

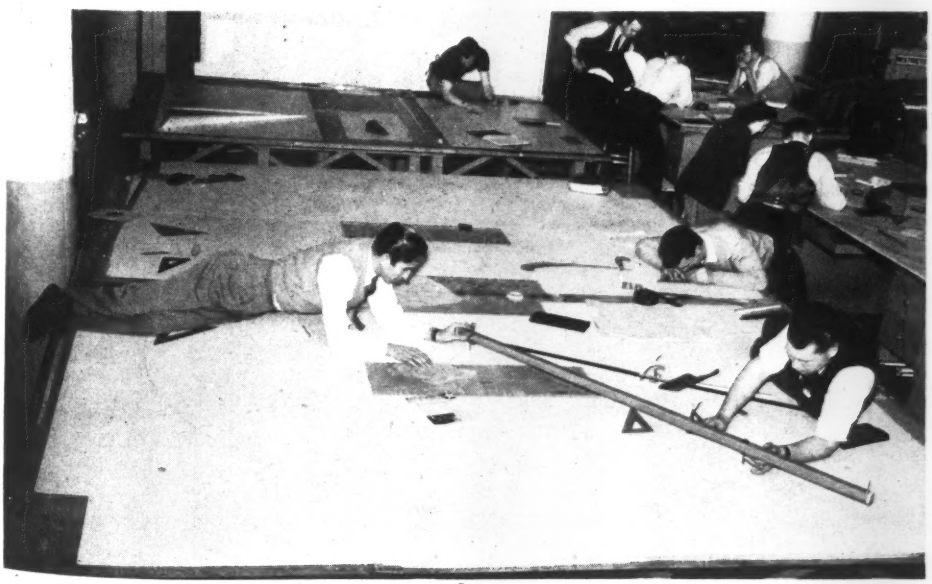
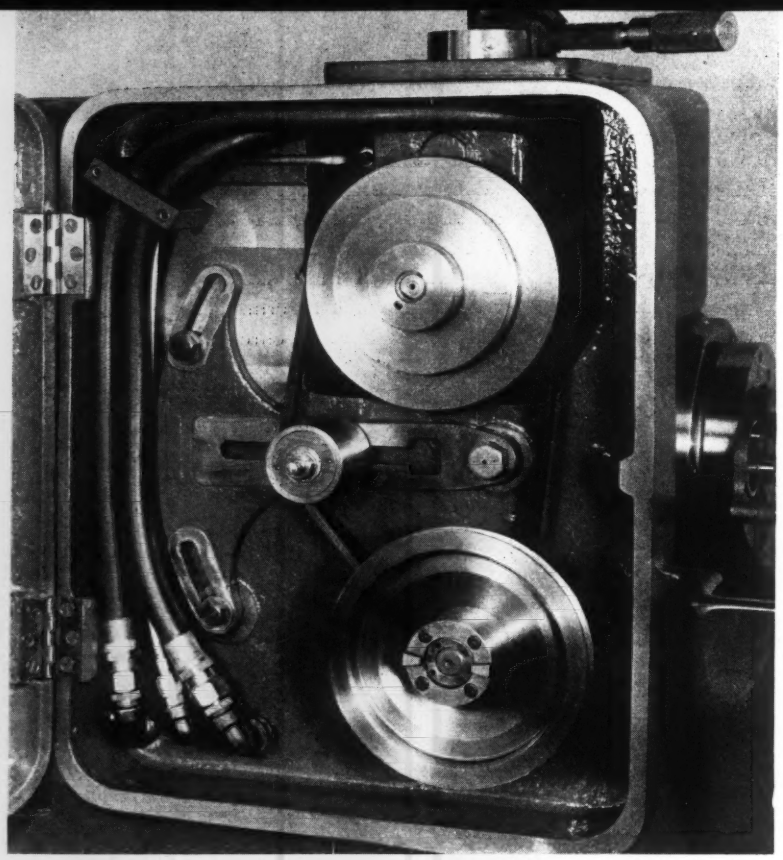


Fig. 5—Large full-scale drawings often require draftsmen to "lay down on the job" as in this instance. Shoes usually are removed to avoid scratching or marring the coated layout sheet



—Photo courtesy Resistoflex Corp.

Fig. 1—Semirigid polyvinyl alcohol hose covered with a braided cotton outer jacket carries fluid at 1200 pounds per square inch to the variable-speed hydraulic work spindle motor on a precision thread grinder

Applyi nt

By John Delmonte
Technical Director
Plastics Industries Technical Institute

IN PLASTIC tubing and fittings there is available to the designer much-needed material for numerous industrial applications. While not an entirely new development, the usefulness of such tubing for machine applications was never fully appreciated until the exigencies of material substitution called attention to their unique properties. Engineers who have become familiar with the merits of plastic tubes are visualizing new methods of incorporating them in their original designs.

Plastic tubes may be classified either as rigid or semirigid, as described more fully in TABLES I and II. Somewhat stiff and heavy-walled tubes such as the laminated phenolics, wrapped asphalt impregnated-paper types, and the rolled asbestos-filled "Haveg", have been known for some years. Of these only the laminated phenolics may be cured under pressure, and these are limited in length to the size of the press and the forming mandrel. On the other hand the asphalt and asbestos-phenolic types have been made in longer lengths. The asphalt impregnated-paper types recently have been proposed as suitable for conducting water or serving as conduit, while the asbestos-phenolics are employed in chemical plant installations for handling corrosive chemicals.

Of other tubes listed in the tables, the majority are extruded thermoplastic materials or rubber-like compounds. A wide variety of diameters and wall thicknesses is available, ranging in some cases from a three-inch outside diameter and .004-inch wall thickness, to a .15-inch inside diameter and 1/16-inch wall. An added advantage in extrusion is that any cross-section may be reproduced such as hexagonal shapes, special flutes, etc.

Many of the more important commercial plastic materials have been listed in TABLES I and II. Their selection for a machine part is predicated by the following factors:

1. Special characteristics possessed by plastic
2. Availability
3. Cost.

Before analyzing the engineering properties of plastic tubes it should be pointed out that while some of them enjoy important applications because of shortages in steel or copper tubing, they too are largely earmarked for wartime applications.

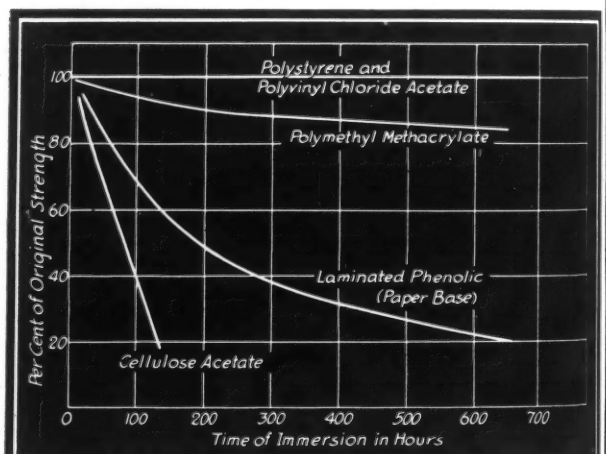
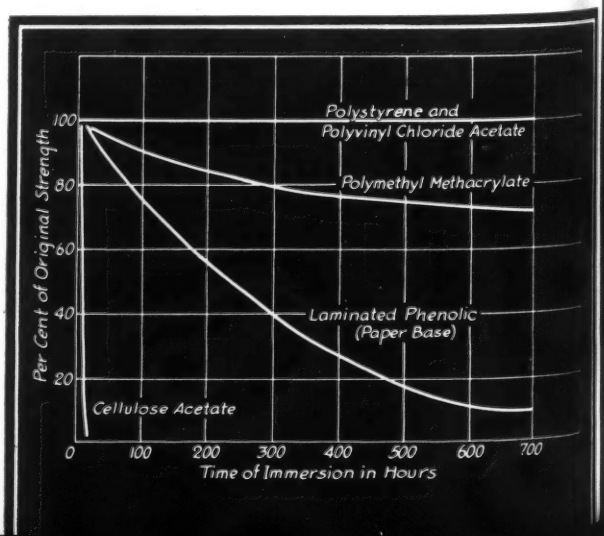


Fig. 2—Above—Effect on plastic materials of immersion in 6.5 N hydrochloric acid is shown by loss of strength

Fig. 3—Below—Immersion in 6.5 N nitric acid as it affects the strength of various plastic materials



ynthetic Tubing in Design

Adaptation of plastic tubing to various design problems has been motivated in many instances by the unusual chemical resistance of the plastic materials. Much is heard of their use in chemical processing equipment, heat exchangers, hydraulic lines, refrigeration units, deicing lines on aircraft, etc. An examination of the excellent chemical behavior will indicate why these installations have merit. In other applications their use has been largely determined by physical considerations or because of the dielectric values of the plastics. For example, semirigid plastic tubing will long outlive metal equivalents where machine vibration induces fatigue failure.

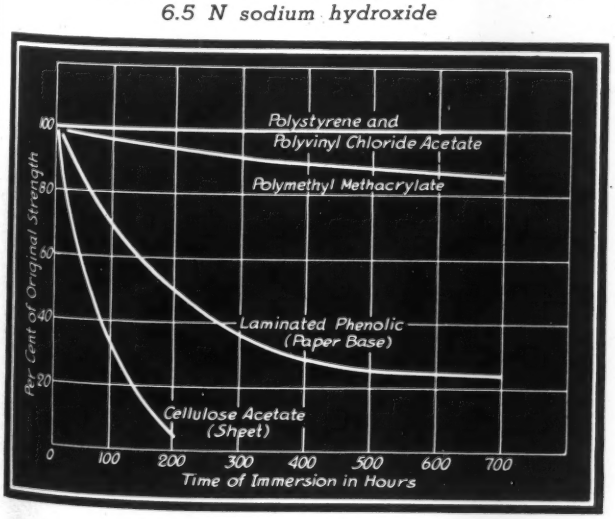
TABLE I

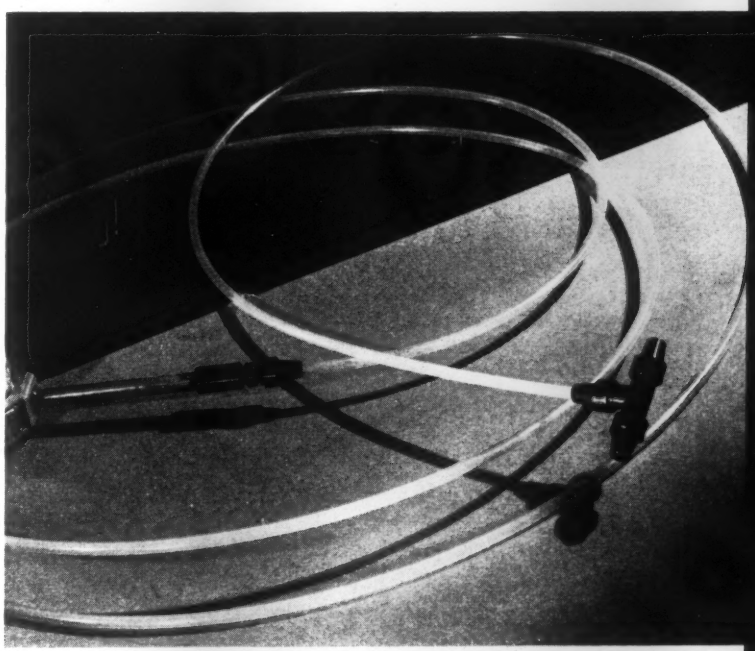
Properties of Rigid Synthetic Tubing Materials

Material	Outstanding Qualities	Typical Tradenames
Laminated phenolic (cloth or paper base)	Thermosetting — withstand temperatures to 250° F. Resists mild acids and alkalies. Good machinability.	Micarta, Insurok, Textolite, Synthane, Spauldite
Rolled tubes of asbestos-phenolic resin	Good chemical resistance adapted to unusual shapes and large sizes	Haveg
Rolled tubes of bitumen-asphalt and paper	Will handle liquids and mild corrosive agents. Low priority material designed to replace metal conduit.	Bermico
Cellulose acetate and cellulose acetate butyrate	Thermo plastic extruded materials. Limited in diameter. General purpose requirements. Easily heat-welded.	Tenite, Lumarith and Plastacele
Polymethyl methacrylate	Cast thermoplastic material. Used where transparent tube structure is imperative. Good machinability.	Lucite and Plexiglas

Also there are instances where the nonelectrical and low thermal conductivity of plastics make them ideal materials. For example, trailing wire antennas employed on patrol planes make connection with the radio apparatus through long laminated phenolic plastic tubes. Not to be overlooked are the strength-weight advantages of the low specific gravity plastics.

Fig. 4—Below—Effect of alkali solutions on plastic materials is shown by loss of strength after immersion in 6.5 N sodium hydroxide





—*Photo courtesy Dow Chemical Co.*

Fig. 5—Injection-molded fittings used with polyvinylidene chloride tubing are readily attached by flaring the ends

Considering more specifically the chemical resistance of plastic materials, *Figs.* 2, 3 and 4 show the effect of prolonged immersion in acids or alkalies upon several well-known plastics. A good quantitative check is possible through examination of the loss in strength of the plastic. Polystyrene and polyvinyl chloride acetate are both outstanding in their general resistance to more common concentrations of acids and alkalies. The resistance of the polyvinyl copolymer resin is due in a large measure to the high proportion of polyvinyl chloride which by itself

TABLE II

Properties of Semirigid Synthetic Tubing Materials

Material	Outstanding Qualities	Typical Tradenames
Polyvinylidene chloride	Extruded thermoplastic. Withstands strong acids and alkalies and most solvents. Readily heat welded.	Saran
Polyvinyl chloride	Good resistance to acids and alkalies and as conduit for corrosive chemicals.	Tygon Koroseal
Polyvinyl alcohol	Will handle many solvents, strong acids and gases. Affected by pure water.	Resistoflex PVA
Chloroprene	Natural rubber substitute offering good resistance to oils and gasoline. Tubes frequently used in chemical laboratories as replacement for rubber.	Neoprene
Polysulphide	Excellent resistance to oils and gasoline. Employed in fuel lines, sometimes as liner.	Thiokol

offers excellent resistance to acids. Use of the latter as linings for tanks handling corrosive chemicals is well known. Not included in the first two charts but also well known for its outstanding resistance to chemicals and acids of all types is polyvinylidene chloride (Saran). Besides its ability to handle acids and alkalies of all concentrations, this plastic is unaffected by acetone or alcohol, or by various refrigerants such as Freon.

Polyvinyl alcohol is also an outstanding material in handling miscellaneous oils, solvents and gases, though mild acids and alkalies have a softening and swelling action due to the effect of water, TABLE III.

The general effect of acids upon plastics differs appreciably from that observed upon metals. Whereas metals are etched and dissolved, those plastics which happen to be attacked are decomposed without any swelling action.

Of practical importance is the problem of providing fittings and connections for joining plastic tubes to one another or to various machine parts. Some materials like the cellulose plastics and polyvinylidene chloride are readily injection molded, thus making available complete fittings for assembly purposes. A few typical injection-molded fittings are shown in *Fig.* 5 assembled to Saran tubing. The parts are molded complete with threads and have the requisite toughness and chemical resistance for long service. The practice of injection-molding cellulose plastic parts is well established, but the handling of polyvinylidene chloride is more critical, requiring specially lined heating chambers in the injection molding machines. These plastic fittings for tubing resemble hard rubber in appearance and feel.

Plastic tubes probably are better adapted to connection fittings and joining together than metal tubes because the ends may be flared out readily with a heated flaring tool. This forms a flange which can be drawn up tightly against a suitable fitting with the aid of a coupling nut. Among other expedients frequently practiced upon semirigid plastic tubes is cementing together with the aid of solvent cements or simply by heat sealing. Heat sealing forms a neat and straight joint although it is adaptable only to simple forms or shapes. Tubes, however, may be butt welded together by this process. A jig is prepared which holds the plastic tubes in their correct angular relationship. The open ends of the tube are placed in contact with a plate heated considerably above the softening point of the plastic. The plate is withdrawn and the tube ends quickly pushed together and pressure maintained while they cool. While some excess softened material will push out, this can be filed or sanded off to leave a clean smooth connection.

Standard hose clamps may be adequate for various installations such as air and gas lines, which often are formed of semirigid plastic tubes covered with a braided cotton outer jacket for abrasion resistance. These tubes serve the function of a rubber substitute, although they probably will outlive the rubber due to superior aging characteristics.

TABLE III

Resistance of Semirigid Tubing to Chemical Action

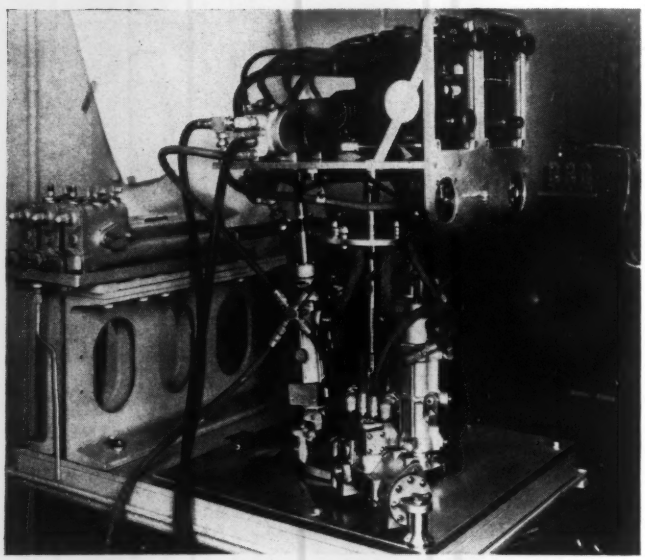
Chemical or Reagent	Polyvinyl Chloride	Polyvinyl Alcohol	Polyvinylidene Chloride
30% H_2SO_4	Excellent	Fair	Excellent
10% HNO_3	Excellent	Poor	Excellent
10% HCl	Excellent	Poor	Excellent
10% ammonium hydroxide	Excellent	Poor	Excellent
Ethyl alcohol	Excellent	Excellent	Excellent
Acetone	Dissolved	Excellent	Fair
Ethylene dichloride	Swollen	Excellent	Poor
Gasoline	Good	Excellent	Good
Toluene	Poor	Excellent	Good
10% NaOH	Excellent	Poor	Good
Water	Excellent	Dissolves	Excellent
Oils	Excellent	Excellent	Excellent

RESISTANCE TO VIBRATION: Among the more interesting features of the semirigid plastic tubes is their resistance to the effects of vibration. Somewhat flexible in nature, they serve the general function of establishing connections between fixed or stationary machine parts and moving or vibrating mechanisms. Among metals soft copper tubing has been used for installations of this character, but the flexible plastic tubes are more durable and much more resistant to fatigue.

In *Fig.* 6 is shown a Servo test bench used in testing Sperry Gyroscope set-ups. Numerous connections between the hydraulic components of the circuit are established with the aid of flexible plastic tubings of polyvinyl alcohol. A chronic problem in applications of this type is the maintenance of temporary connections to a variety of hydraulic lines under difficult conditions. An ever-present hammer pressure condition which shortened hose life considerably was alleviated through the use of plastic tubing. Hose connections must withstand flexing in all axes up to 30 degrees, placing severe mechanical strain on flexible connections. *Fig.* 7 demonstrates another installation of this type of tubing.

There are other applications of plastic tubing, as in paint and lacquer spraying equipment, where the good solvent resistance of certain types of semirigid tubing may be used to advantage. Polyvinyl alcohol tubing, for example, is reported to outlive the rubber lines which it replaces by 300 to 500 per cent. The tubing is unaffected by the solvents or oils encountered in lacquer formulations.

(*Continued on Page* 188)



—*Photo courtesy Resistoflex Corp.*

Fig. 6—Polyvinyl alcohol hose lines for this testing machine used in checking aircraft equipment overcame difficulties due to pulsation

Design Roundup

NE vs Standard Alloys

CONSIDERABLE difference of opinion exists among engineers as to the types of steels which should be specified for given machine parts. Some feel that the National Emergency steels are just as good as alloy steels for certain purposes. Many take the position, however, that they will drop the substitutes now being used and return to alloy steels as soon as possible, pointing out the huge additional electric furnace capacity available for producing these steels.

Just two examples will indicate the range in thinking. A machine tool builder found it necessary to use an NE steel in place of a chromium-nickel-molybdenum steel for a large 36-inch gear. Experience to date has convinced this builder that it would be advisable to go back to the alloy steel after the war. Further, a maker of diesel engines formerly used SAE 4615 for wrist pins and subsequently substituted NE-8620 and NE-9420. Now it is planned to change over permanently to an induction-hardened .50 per cent carbon steel for these pins.

Modernizing Railway Car Trucks

LOOKING to the future, one of the eastern railroad equipment builders is scouting the possibilities for marketing a car truck fabricated almost entirely from 18-8 stainless steel strip. The new truck, a model of which already has been made, employs spot-welded rather than the usual cast-steel construction and represents a radical departure from conventional design.

If actually placed on the market the truck is likely to employ internal expansion brakes rather than the usual outside shoe type. The new brake has more braking surface and is protected from the weather—thus providing faster, more positive stops, especially for high-speed trains.

Conserves Space and Manpower

DEVELOPMENT of a new type of machine for performing multiple drilling operation on aircraft cylinder heads is one of the latest accomplishments of the engineers in the machine tool field. Possessing distinct advantages, from the standpoint of space occupied, over the straight-line series of machines now generally used, the new machine is arranged in rectangular form. Loading and unloading stations therefore are adjacent, while control and adjustment are simplified.

As the cylinder heads progress along their rectangular path they are stopped at twenty separate stations, at ten of which 22 major drilling, boring and facing operations are performed. Minor operations which can be carried out more economically on small high-speed machines are not included. Feeds are hydraulically operated, the electrical control mechanisms being arranged in a large cabinet in the center of the rectangle. A pushbutton control panel at one side is provided with colored lights which, in the event of a stoppage, indicate the point where trouble has occurred.

The machine is strictly special, and any radical departure from the present cylinder head design for which the machine was built would involve major reconstruction.

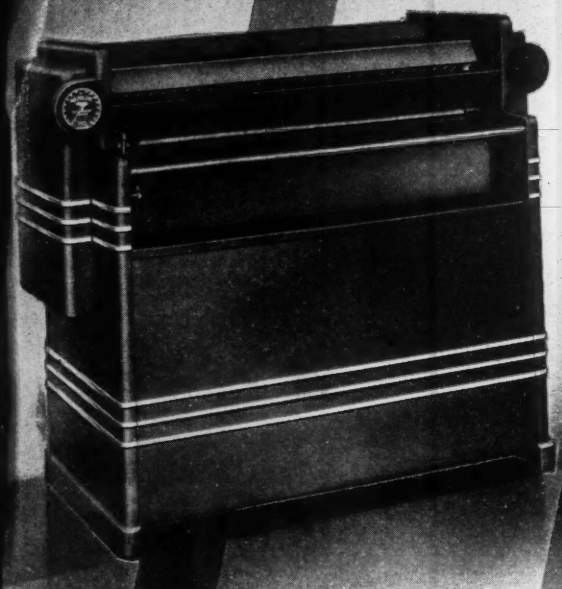
Shot-Peening's Influence

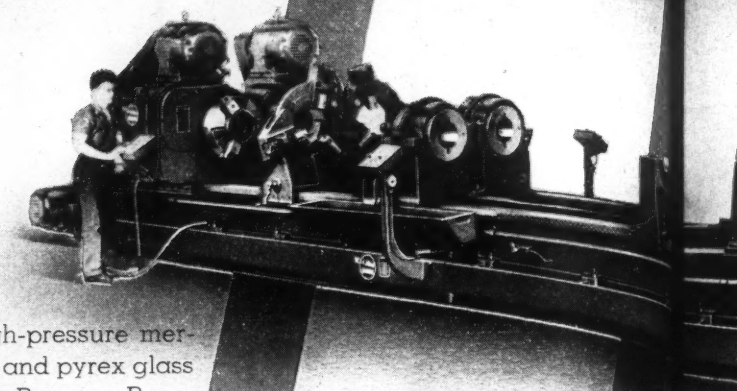
DEVELOPMENTS in shot-peening may lead to changes in design of machine parts and possibly some revisions in material specifications. At least one of the large makers of shot-blasting equipment considers the peening process of sufficient importance to launch a research program for the purpose of uncovering further data on the changes in physical characteristics of machine parts effected by it.

It already is well established that cold-working by shot-peening results in improvement in fatigue life of machine parts, this being based largely on the work of J. O. Almen, Research Laboratories Division, General Motors Corp. To cite only one example, it has been found that the fatigue life of Allison aircraft engine crankshafts has been increased 30 per cent by peening.

Some familiar with the process also are of the opinion that bright polishing is unnecessary and that the dull, slightly mottled finish produced by shot-peening is just as satisfactory, especially for machine parts used internally where appearance is not a factor. From a cost standpoint the savings are considerable.

As an interesting sidelight, shot-peening is employed essentially for surface preparation of military equipment parts prior to painting in an armorplate plant which only lately has gone into production. However, the process also has the effect of healing small fractures in the extremely hard plate and uncovering larger flaws not revealed by other means of inspection.

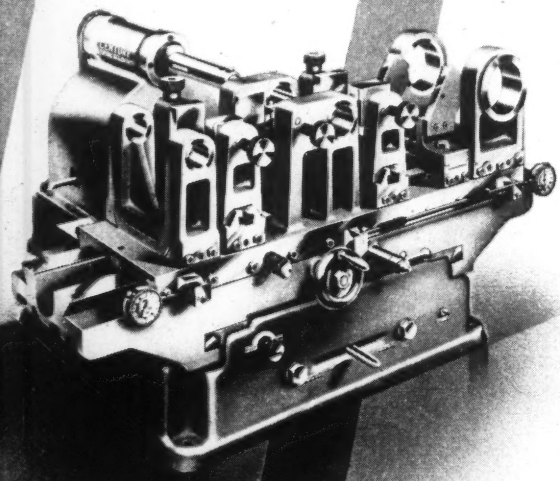




Left—Quartz high-pressure mercury vapor lamp and pyrex glass cylinder on the Paragon-Revo-rite blueprinting machine are cooled by a squirrel-cage exhaust fan. Method of enclosing entire lamp insures uniform light distribution and prevents escape of ozone fumes into the surrounding atmosphere

Above—Tools on the B... spindle d... cylinder boring machine are indepen... draulically actuated slides. Spindle ... draulic feed may be contro... either ... pushbutton stations on conv... side ... machine. Used for boring ... landi... struts and recoil cylinders, the ... has ... of twenty-five inches and ... of twelv...

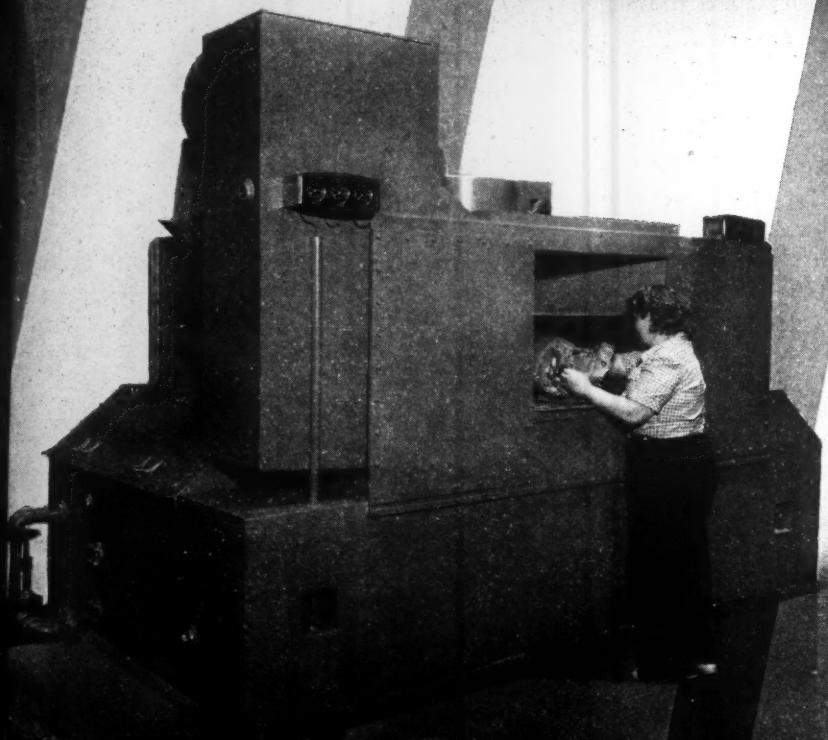
Right—Table of Century connecting-rod boring machine is actuated and controlled by a hydraulic system in which the oil is energized by air pressure. Boring bar is driven by a separate motor through a V-belt running on stepped pulleys which provide for speed changing. Three-pointed mounting of base casting prevents distortion and eliminates need for leveling



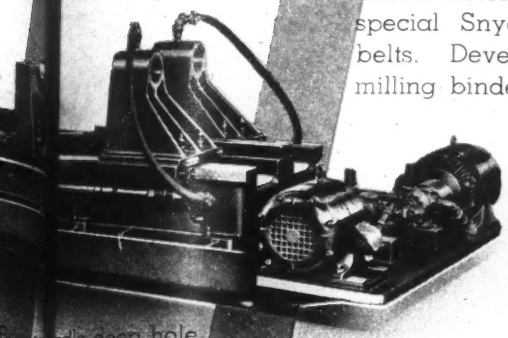
Machines shi... the Gs...

(For new machine listing... 98)

Below—Turntable of Industrial Washing Machine metal parts clean... driven by variable speed unit fe... through reducer to worm and pinion. Because floating grit is encountered, grease-packed babbitted bearings are utilized. Plain carbon steel is used for tanks and housing which, during operation, are coated by the cleaning solution with a rust-inhibiting film



Right—Handwheel operates a right and left-hand screw to secure work between a V-block and button on the Whitcomb quickcenter. Block is hardened and ground, and is fitted with a phosphor bronze nut. Step-cone V-belt pulleys drive provides adjustable speed for the centering drill spindle



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landing gear
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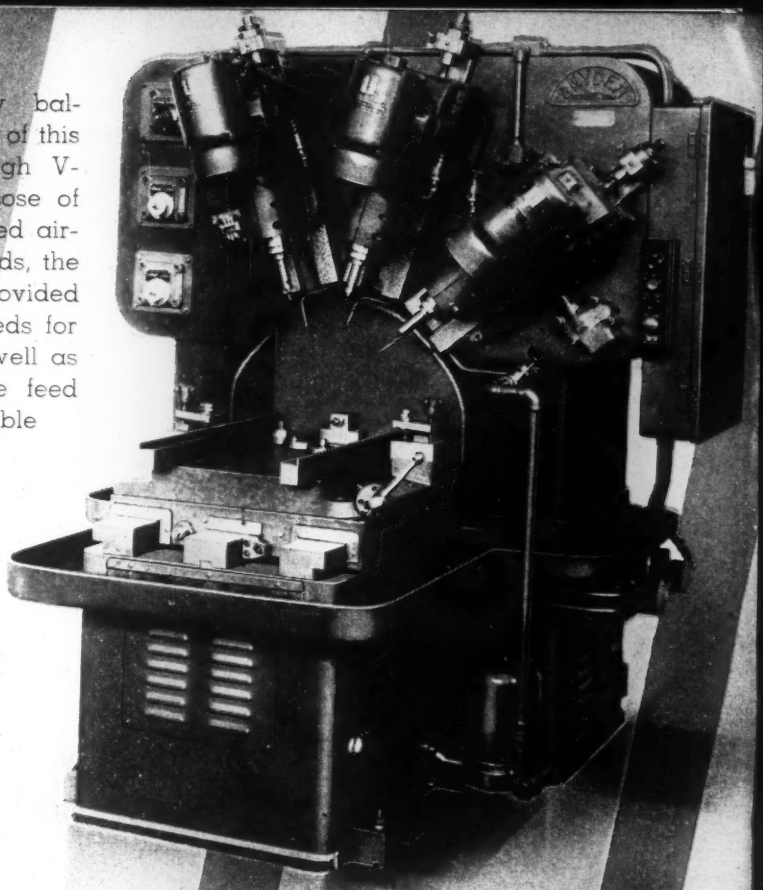
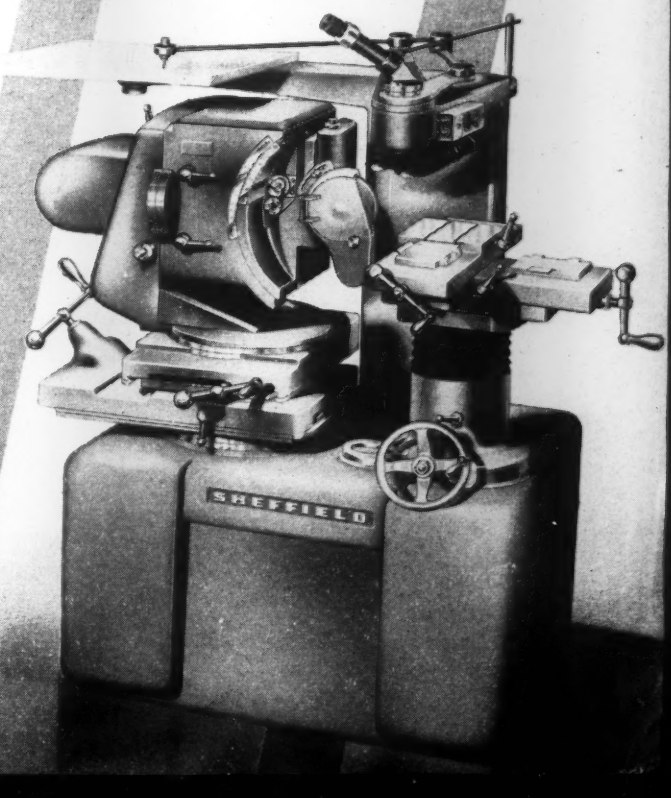
listing

Right — Individual dynamically balanced motors drive the spindles of this special Snyder machine through V-belts. Developed for the purpose of milling binder bar slots in forged aircraft cylinder heads, the machine is provided with hydraulic feeds for each spindle as well as for the transverse feed of the fixture table



Left—Simultaneously testing and prestretching five separate aircraft control cable assemblies, the Parker hydraulic stretcher uses a timing meter which may be set to pull at a predetermined tension for a period of from three seconds to twenty minutes. Power for the five hydraulic cylinders is furnished by a variable displacement pump equipped with automatic shut off

Right—Eliminating need for templates the Sheffield micro-form grinder produces parts of any profile directly from a scale drawing made fifty times full size. Stylus on long arm of pantograph is moved from point to point along drawing while grinding wheel is fed so that cutting edge works toward crosshair intersection in microscope mounted on the short arm



MACHINE Editorial DESIGN

Watch Progress in Related Fields— for Now and "After"

WAR is too costly in lives to make worth while any credit it might be given for bringing about rapid development. Yet the fact remains that the current conflict—as with earlier wars—is responsible for speeding up progress in many fields such as aeronautical, electrical, medical, chemical and mechanical to a point that otherwise could not have been reached for several decades.

In the aircraft field it was a comparatively rare thing, prior to the war, for an airplane to fly the Atlantic. Now it is too commonplace to receive notice. Electronics—in its broader applications—was in its infancy in 1939 but is now a primary factor in some of the most effective wartime equipment such as radar, tanks and battleships. The medical profession has applied the new sulpha drugs with outstanding success, while the chemical field can count among its publicly known advances the increased development and production of synthetic rubber and high-octane gas.

To the credit of the engineers in charge of mechanical design goes the fact that, apart from those advances peculiar to his specific line of work such as the development of tanks, jeeps and the less dramatic though just as essential production machinery, he has played a large part in developments created in other fields of wartime activity. He it is who, through mechanical equipment, is responsible for the actual consummation of many of the ideas and principles developed outside his particular sphere.

In turn, the designer of machines owes much to engineers more closely connected with other branches of the industry such as metallurgical and hydraulic. Were it not for the development of new alloys of the less-critical elements, the designer might have made a relatively poor showing. Many lessons, too, are to be gained from the hydraulics engineer who, as cited in the leading article in this issue, is faced with the production and use of hydraulic equipment of maximum lightness, accuracy and reliability for application to today's aircraft.

Many of these outgrowths of the war can still be utilized to the fullest advantage by the alert designer of wartime equipment. And many more may well be kept in mind for consideration in the design of the peacetime machines to follow.

L. E. Jermy

Calculating Buckling Load of Helical Compression Springs

By Carl P. Nachod
Nachod & United States Signal Co.

CALCULATION of the buckling load of a helical compression spring is greatly facilitated by use of the nomogram on Page 134. This chart is based on information included in the article "When Helical Springs Buckle!" by A. M. Wahl, which appeared in the May, 1943, issue of MACHINE DESIGN.

Compression springs may be held fixed at the ends, *Fig.* 1*a*, or may be pivoted or hinged, *Fig.* 1*b*, the buckling load for the latter condition evidently being lower. In the article

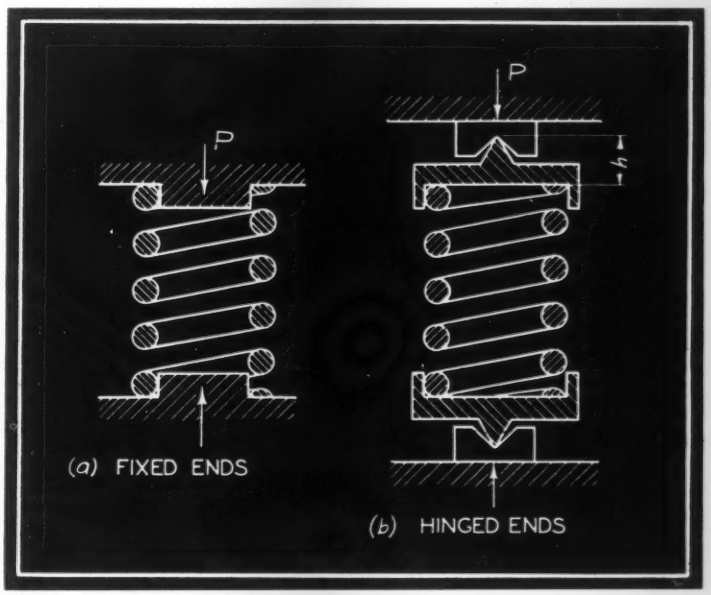


Fig. 1—Above—Critical buckling load of an axially loaded helical spring depends on end support

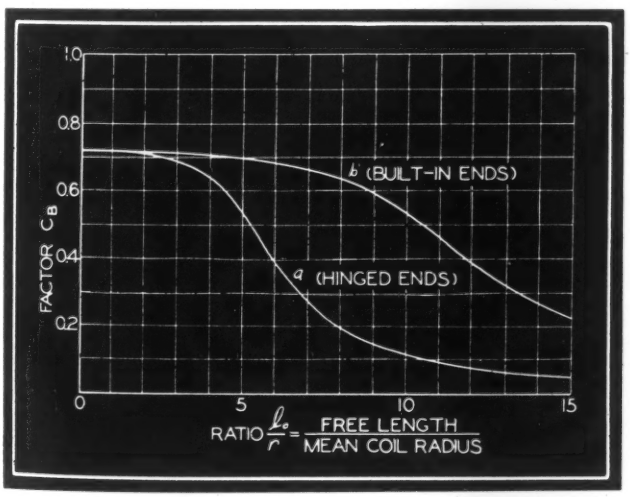


Fig. 2—Left—Curves show buckling load factor for springs of various slenderness ratios

referred to it is shown that the buckling load is given by the equation

$$P_{cr} = C_B l_o C_k \quad \ldots\ldots (1)$$

where C_k is the spring constant or gradient, pounds per inch of deflection, l_o is the free length of the spring, inches, and C_B is a factor depending upon the ratio l_o/r between the spring length and the mean radius of the coil (slenderness ratio). Variation of the factor C_B with the ratio l_o/r is shown in *Fig.* 2 for the two types of end conditions. For constant slenderness ratio it will be seen that the buckling load increases directly with free length and with spring gradient.

In the nomogram on Page 134 any two computing secants, each passing through the appropriate three scales and intersecting on the turning scale will give this load. On the scale for l_o/r the corresponding values of C_B are plotted on log scales from *Fig.* 2 but are marked for l_o/r. The scale is graduated for both end conditions.

EXAMPLE: Using the same figures as in the example on Page 98 of the May issue, $l_o = 6$ inches, $r = \frac{3}{4}$-inch and the spring constant, C_k, is 142 pounds per inch; then the value of l_o/r would be 8. Entering the chart at this value on the slenderness ratio scale for fixed ends and connecting it to the value 6 on the free-length scale gives the secant *I*. From the intersection of this secant with the turning scale a secant *II* is projected to the value 142 on the spring-constant scale. This secant intersects the buckling load scale at 545, which is the critical buckling load.

For those interested, moduli of scales, reading from left to right, are 4, 40/19, 10, 40/9 and 8. The spacing ratio of scales C_k, P_{cr} and the turning scale is 9:10. Spacing ratio of scales l_o/r, turning scale and l_o is 5:4.

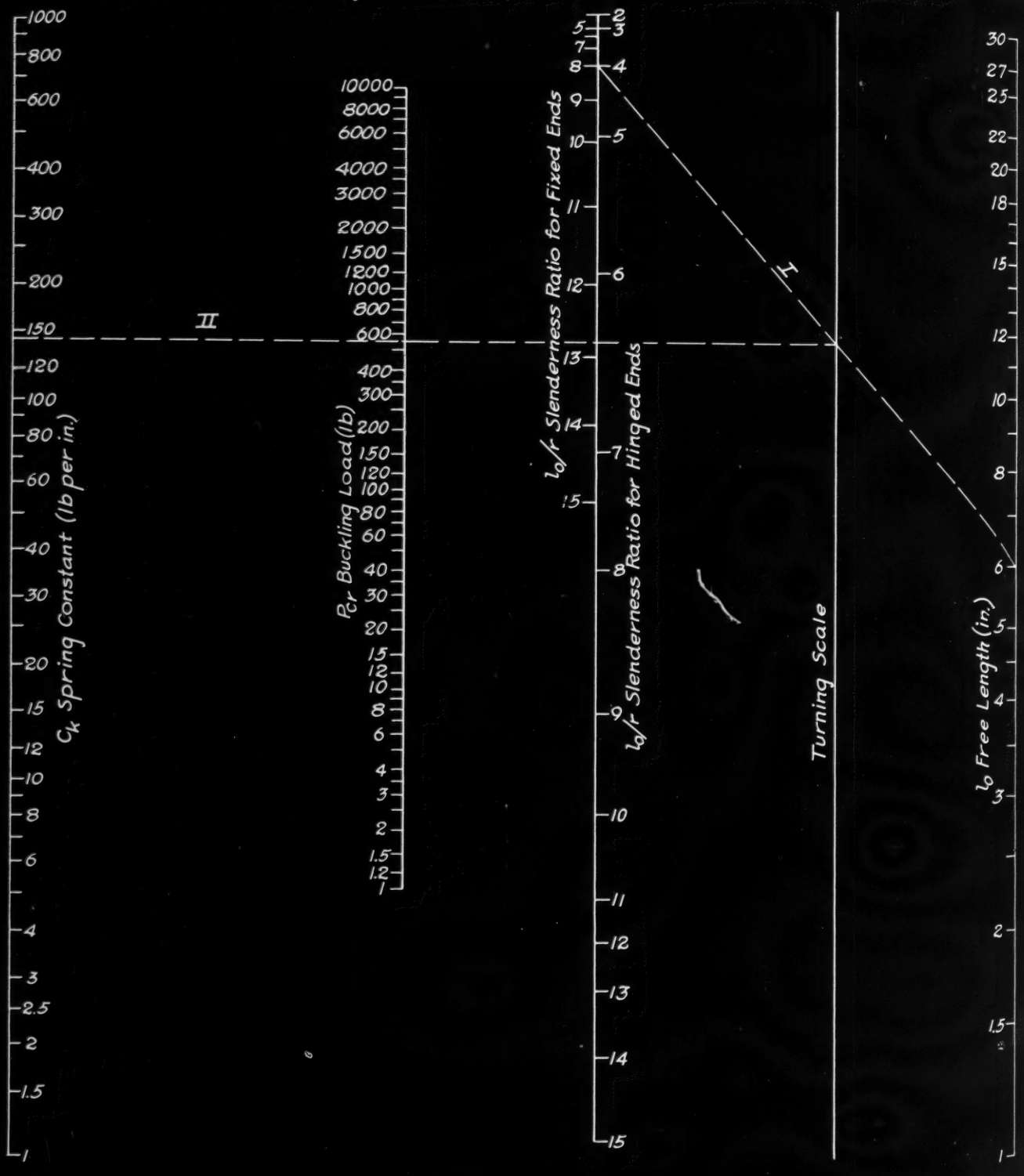
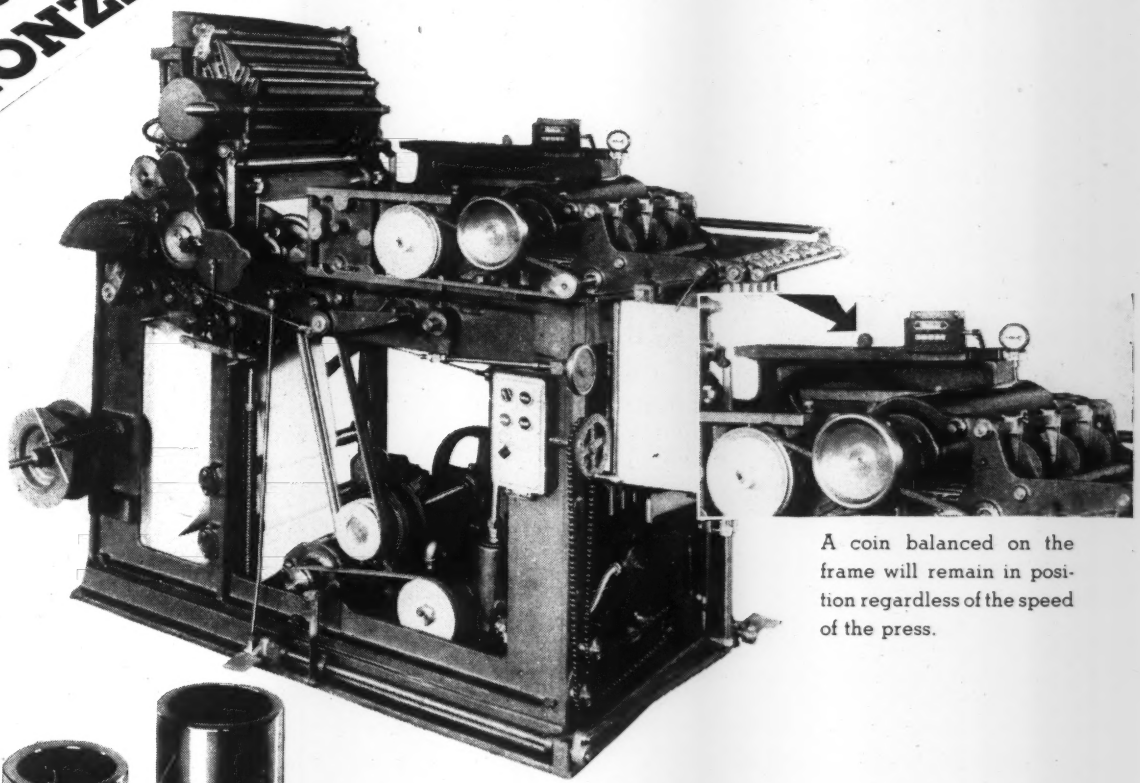


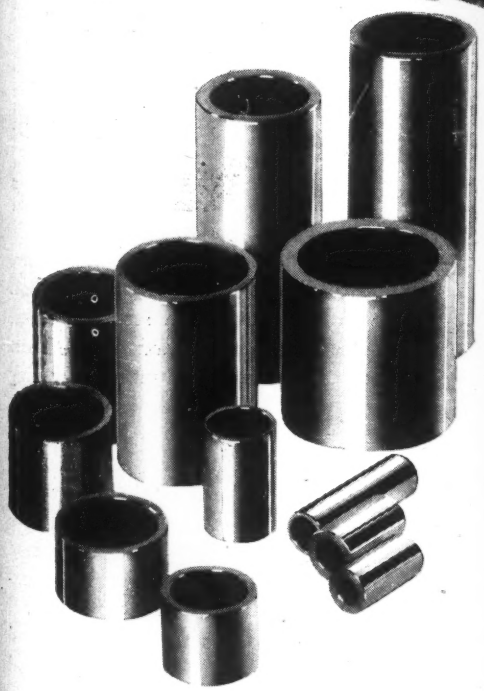
Chart for Buckling Load of Helical Compression Springs
C_k Spring Constant (lb per in.)
P_{cr} Buckling Load (lb)
l_o/r Slenderness Ratio for Fixed Ends
l_o/r Slenderness Ratio for Hinged Ends
Turning Scale
l_o Free Length (in.)
I
II

JOHNSON BRONZE

SLEEVE TYPE BEARINGS



A coin balanced on the frame will remain in position regardless of the speed of the press.



Eliminate VIBRATION

THIS Offset Press, manufactured by the Pittsburgh Lithograph Press Company, provides an excellent example of how SLEEVE TYPE Bearings eliminate vibration. You can balance a coin on the frame of this press . . . start it operating from a dead stop . . . bring it up to a speed of 27,000 impressions per hour . . . shut it down to a dead stop—and the coin will remain undisturbed.

This is the type of performance manufacturers can expect when their SLEEVE BEARINGS are correct in design . . . properly installed. Helping manufacturers of *all* types of equipment select the correct bearing for each application has been a welcome assignment for Johnson Bronze for more than 35 years.

If you have a bearing problem . . . either for present production . . . or for postwar planning . . . consult with Johnson Bronze. A qualified Sales Engineer is as near as your phone. Why not call him in TODAY?

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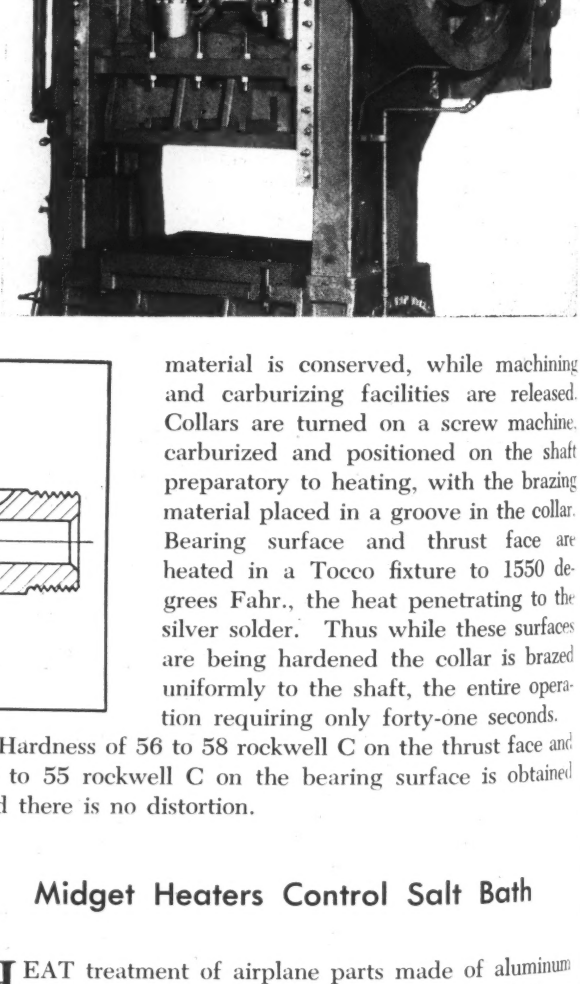
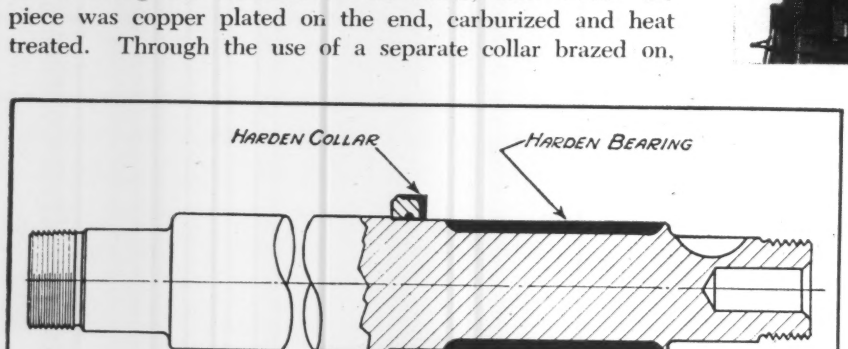


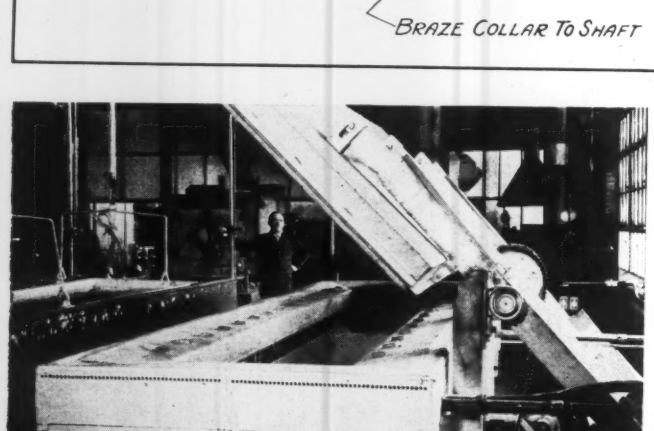
POWER to the 150-ton Rockford double-crank press shown at right is transmitted through a Fawick Airflex clutch mounted on the crankshaft. Air pressure admitted to the inside of a tire-like rubber gland controls the capacity of the clutch and may be set so that clutch slips on overload. Flexibility of the side walls absorbs torsional shocks and vibration. Operation is controlled by an air valve which automatically disengages the clutch after one cycle, no lever, cam or other shifting means being necessary.

Hardens and Brazes at One Heating

USED in diesel engines for Army tanks, the balancer shaft shown below formerly was turned down from bar stock having the diameter of the collar, after which the piece was copper plated on the end, carburized and heat treated. Through the use of a separate collar brazed on, material is conserved, while machining and carburizing facilities are released. Collars are turned on a screw machine, carburized and positioned on the shaft preparatory to heating, with the brazing material placed in a groove in the collar. Bearing surface and thrust face are heated in a Tocco fixture to 1550 degrees Fahr., the heat penetrating to the silver solder. Thus while these surfaces are being hardened the collar is brazed uniformly to the shaft, the entire operation requiring only forty-one seconds.

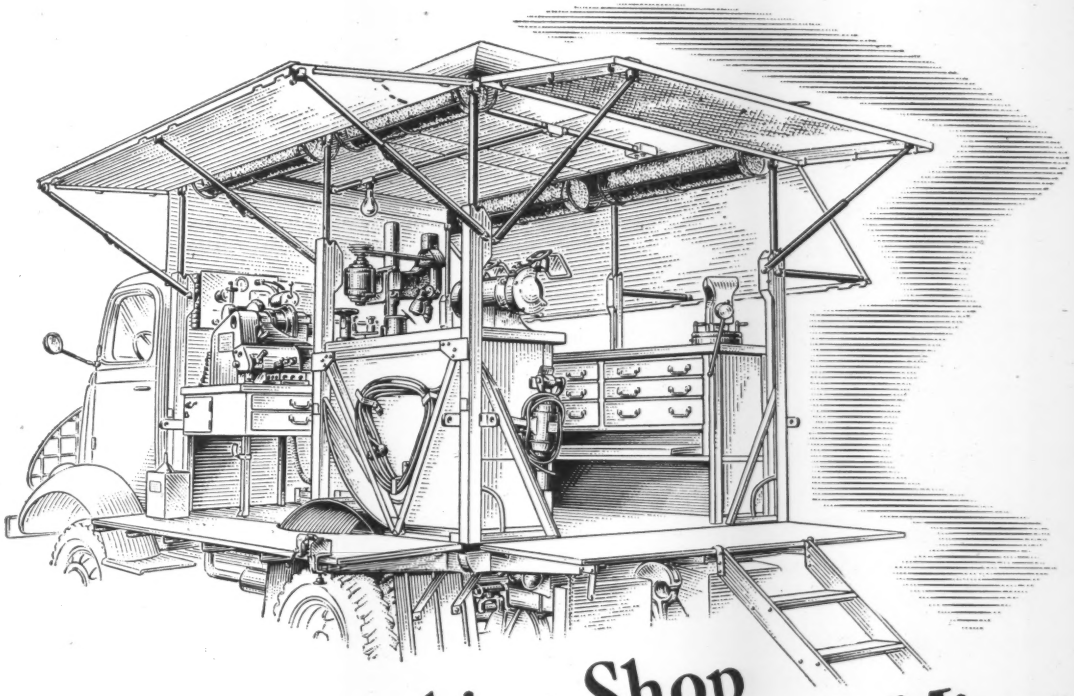


Hardness of 56 to 58 rockwell C on the thrust face and 50 to 55 rockwell C on the bearing surface is obtained and there is no distortion.



Midget Heaters Control Salt Bath

HEAT treatment of airplane parts made of aluminum alloys is done in the G. E. salt-bath furnace shown at left. Operating temperatures up to 1000 degrees Fahr. are maintained by twenty-four 8.33-kilowatt G. E. midget heating units immersed directly in the molten salt. Other uses of midget immersion heaters include heating lubricating oil for tanks, planes and other equipment, also melting and maintaining molten lead, solder, tin, babbitt and alloys for wartime metal parts.



The Mobile Machine Shop Prizes a Part from the Food Mixer

IT MIGHT SEEM strange that a truck equipped to make repairs in the field should find anything of value in a household kitchen mixer. The food mixer is a "lady's man" and so must be trim, light in weight, and stout-hearted. That's why food mixer manufacturers prefer Torrington Needle Bearings—their compact size and ease of lubrication give this modern kitchen equipment much of its "sex appeal."

The mobile machine shop, on the other hand, is *designed* for repair work. Rugged, hard-driven, it is equipped with various kinds of machine tools to do just that. But it was the repair and servicing of planes, tanks and other mechanized equipment "knocked out" in battle that our Armed Forces had in mind when they designed the mobile machine shop. And the Needle Bearing's adaptability to machine tool design looked to Army engineers, as it did to the food mixer people, like just their dish. As it turned out, there were *other* features on the bill of fare of this unusual anti-friction bearing that any repair crew in the field would welcome—the ability to stand up in the severe service a mobile machine shop knows... effective lubrication, low coefficient of friction, increased efficiency of operation...and, of course, the fact that it needs so little attention.

NEEDLE BEARINGS— ALL TYPES—ALL SIZES

NEEDLE BEARINGS TYPE DC are complete, self-contained units consisting of a full complement of rollers and a drawn, hardened outer race. They offer the advantages of small size, low cost, high capacity—and easy installation.

NEEDLE BEARINGS TYPE NCS consist of a full complement of rollers and a relatively heavy hardened outer race. They are furnished with or without inner races. Needle Bearings Type NCS are adaptable to heavier loads than Needle Bearings Type DC.

NEEDLE ROLLERS TYPE LN are produced in a range of types and sizes for assembly on the job into low-cost, high-capacity, anti-friction bearing units. Our engineering department will be glad to advise on the correct size and type for any application.

THE POINT IS YOUR POSTWAR DESIGNS

In considering ways to improve your own product's design for postwar, there's more than one useful idea in the Needle Bearing. For war work has awakened many of *your customers* to the advantages, in performance and cost economy, of compact design, savings in weight, infrequent lubrication and long service life—features which identify the Torrington Needle Bearing. Torrington engineers will be glad to assist you in adapting this new-day bearing to your future designs. Catalog No. 109 listing sizes, ratings and typical applications will prove helpful, also, as preliminary information.

THE TORRINGTON COMPANY

Established 1866 • Torrington, Conn. • South Bend 21, Ind.

Makers of Needle Bearings and Needle Bearing Rollers

New York Boston Philadelphia
Detroit Cleveland Seattle
San Francisco Chicago Los Angeles
Toronto London, England

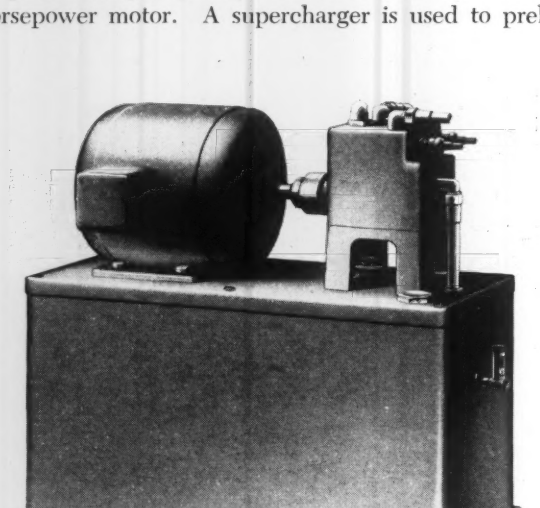
LET'S GO! U.S.A. KEEP 'EM FLYING

TORRINGTON NEEDLE BEARINGS

New PARTS AND MATERIALS

Supercharged Hydraulic Pump

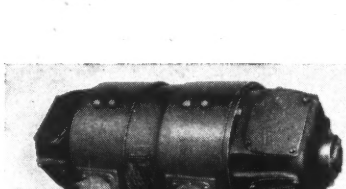
BEING placed on the market by Anker-Holth Mfg. Co., 332 South Michigan avenue, Chicago 4, is a supercharged combination high and low-pressure oil hydraulic power unit, called the Hi-Po. The unit meets the needs of a high-power hydraulic unit, developing pressure in the 3000-pound range, quickly delivered with the use of a ½-horsepower motor. A supercharger is used to preload



the piston chamber and reduce pulsation to a minimum. Pump and motor are mounted directly on the oil reservoir using SAE 20 motor oil as the pressure medium. Low-pressure by-pass control having a range up to 300 pounds is built into the pump body. Both high pressure and low pressure can be controlled individually on the power lines or through automatic control to meet application needs.

Two-Bearing Motor-Alternator Sets

DESIGNED for converting direct current to alternating current for various applications, a new line of two-bearing (ball), 3600 revolutions per minute motor-alternator sets in integral ratings up to 5 kva, single-phase, have been announced by General Electric Co. The direct-current motor of the set drives the alternator, which has a field connected in series with the motor armature. An increase in the alternator load causes an increase in the motor load, so that increased direct current is drawn from the line. This greater current strengthens the alternator series field, tending to maintain a constant alternating-current voltage. Motor and alternator are similar in that armature windings are on the rotating elements and the



fields are stationary, being attached to the frames. A solid shaft, supported by a ball bearing at each end, serves to mount the rotating members of both the motor and the alternator, thus eliminating a number of parts and making a considerable saving in weight. Sets are easy to disassemble; the complete rotating unit may be pulled out of the stator merely by removing an end shield.

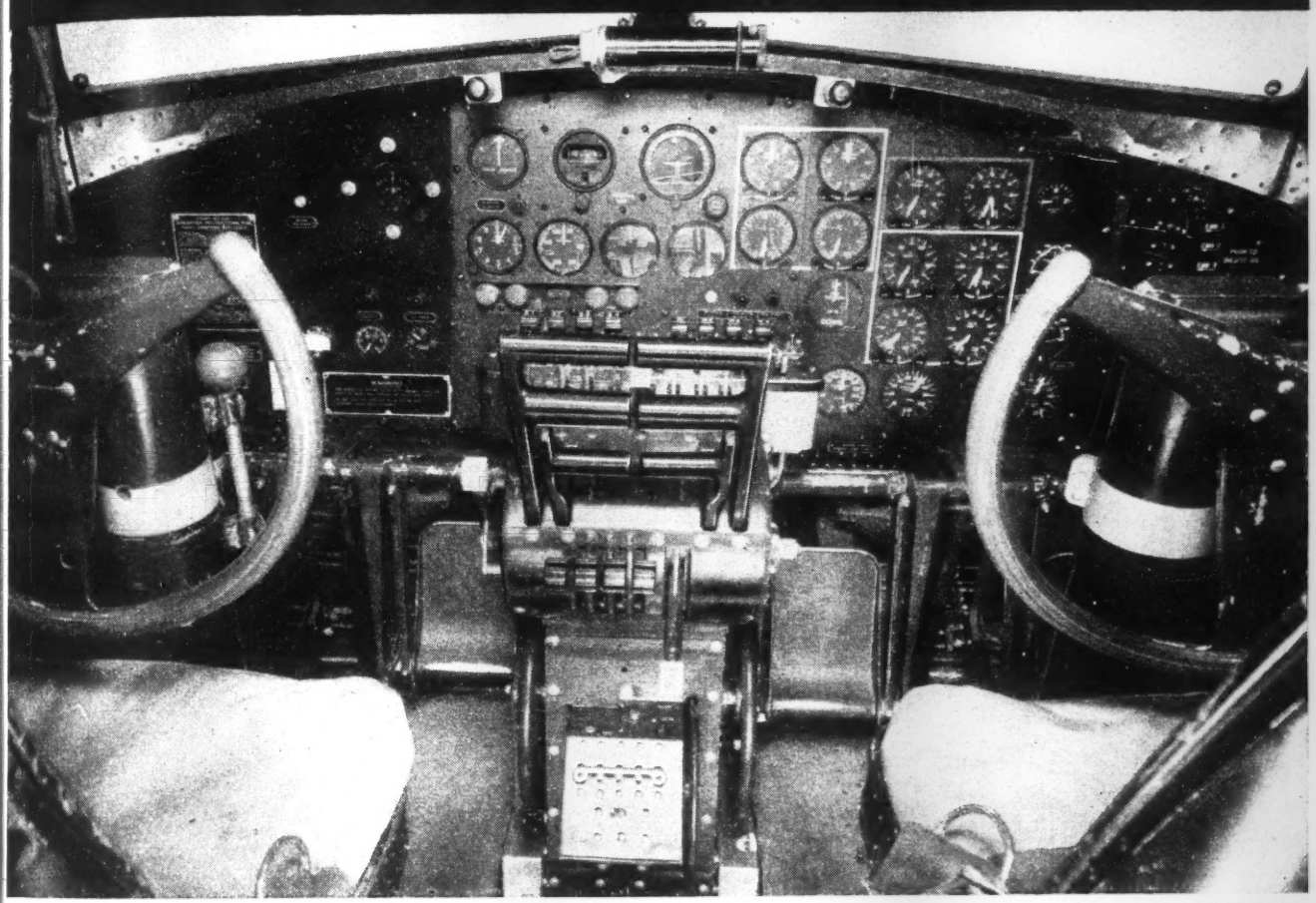
Multiple-Speed Pushbutton

PROVIDING up to five speeds in a single pushbutton, Northern Engineering Works, 2615 Atwater street, Detroit, has introduced its new multiple-speed pushbutton. Each button provides one to five speeds on the device controlled. As a button is pushed in, it moves a metal cylinder to wipe over a succession of contacts. These are steel balls mounted on springs, stiff enough so the operator can "feel" the successive clicks and not stiff enough to make the button difficult to operate. While designed primarily for crane and hoist operation, this simple and sturdy control is easily adaptable to any machine where pilot or relay circuits are used. A battery of these buttons mounted in a pendant is shown in the accompanying illustration.

Handwheel Introduced

HANDWHEELS embodying safety features are being offered by Gibbons Mfg. Co., 11 Gordon street, Worcester, 4, Mass., for all types of wood and

HELPING DIALS TELL THE TRUTH



Boeing Flying Fortress

ANOTHER VITAL JOB HOUGHTON'S V PACKINGS ARE DOING WELL

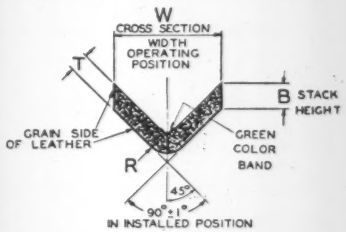
Back of many of the dials in this maze on the instrument panel of the modern plane are hydraulic lines which operate vital controls. Those lines must be sealed against leakage at any pressure, temperature or altitude.

VIM Leather V Packings are used almost universally wherever this type of seal—impregnated to resist oil—is specified. You will find Vim Leathers in such vital parts as the automatic pilot, starter, shock strut, windshield wiper, feathering valve, stand-by hand pump, wing flap control, electric pressure switch, fuel oil pump, magneto shaft and propeller.

And just as aeronautical engineering relies on hydraulics, so do countless other mechanisms, from tiny valves to huge presses.

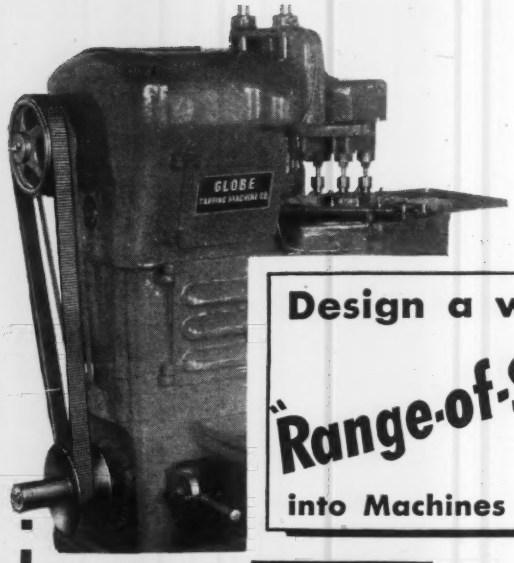
Whenever your design work gets to the stage of sealing a mechanism, then it is time to call in the Houghton hydraulic engineer for help on the packing installation. He is at your service. E. F. HOUGHTON & CO., Philadelphia and all principal cities.

Desirable Proportions for Army Air Force Leather "V" Packings



W	B +.000 −.010	T	R
3/16	.083	1/16	5/64
1/4	.083	1/16	5/64
5/16	.083	1/16	5/64
3/8	.083	1/16	5/64
7/16	.105	5/64	3/32
1/2	.105	5/64	3/32

HOUGHTON'S Engineered VIM Leather Packings

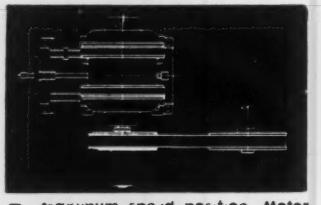


Design a wide "Range-of-Speeds" into Machines you build

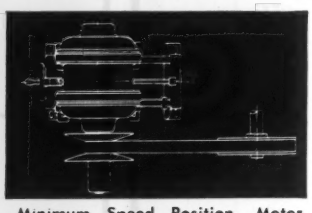
IDEAL Wide V-Belt Pulley included in design of tapping machine. Permits infinitely variable control of work-speed between 15 and 45 cycles per minute.

IDEAL VARIABLE SPEED

Speed changed at will WITHOUT STOPPING



Maximum speed position. Motor close to driven sheave. V-Belt at largest pitch diameter.



Minimum Speed Position. Motor away from driven sheave. Pulley open to smallest pitch diameter.

Infinite range of speed up to 3 to 1 ratio. Provide the RIGHT Speed to match each job!

Give the machines you build greater versatility. Equip them to change speeds to suit different jobs—different operators—different materials. Install inexpensive IDEAL Variable Speed. By easy hand adjustments, your machines can be speeded up or slowed down instantly, while running, giving them an infinite range of speed up to 3 to 1 ratio.

Advantages . . .

- Both halves of sheaves move, assuring perfect belt alignment.
- Easy to install—belt center line fixed.
- Infinitely variable speed up to 3 to 1 ratio.
- Minimum overhang to belt center line.
- Curved pulley faces assure full belt contact at all driving diameters.
- Dependable—all metal construction with balanced sheaves.

FREE . . . .

TRANSMISSION HANDBOOK

Get this 52-page book filled with new transmission ideas. Contains detailed data, on Variable Speed control equipment—technical engineering information, applications—how installed. Send for your copy today!

Submit your transmission problems to IDEAL engineers.

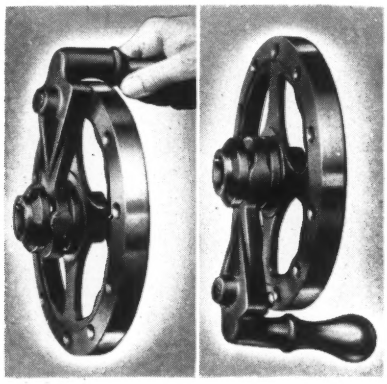
IDEAL Sycamore

★ IDEAL COMMUTATOR DRESSER CO ★

1059 Park Avenue **Sycamore, Illinois**

"Sales Offices in all Principal Cities"

metalworking machines. They are especially recommended for rapid-traverse machines where handle wheels or cranks are in faster motion and the danger is greater. To strike the handle in any way will not engage it with

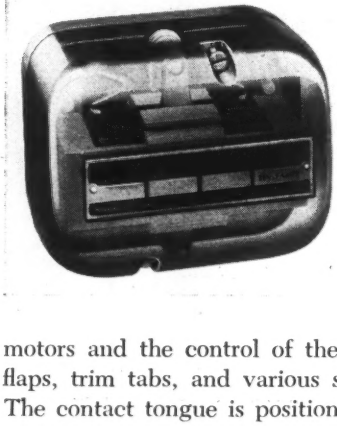


the wheel while in or out of motion. The wheel keyed to the shaft permits necessary adjustments without the use of the safety handle. Striking or catching of operators' clothes while wheel is in motion is also prevented.

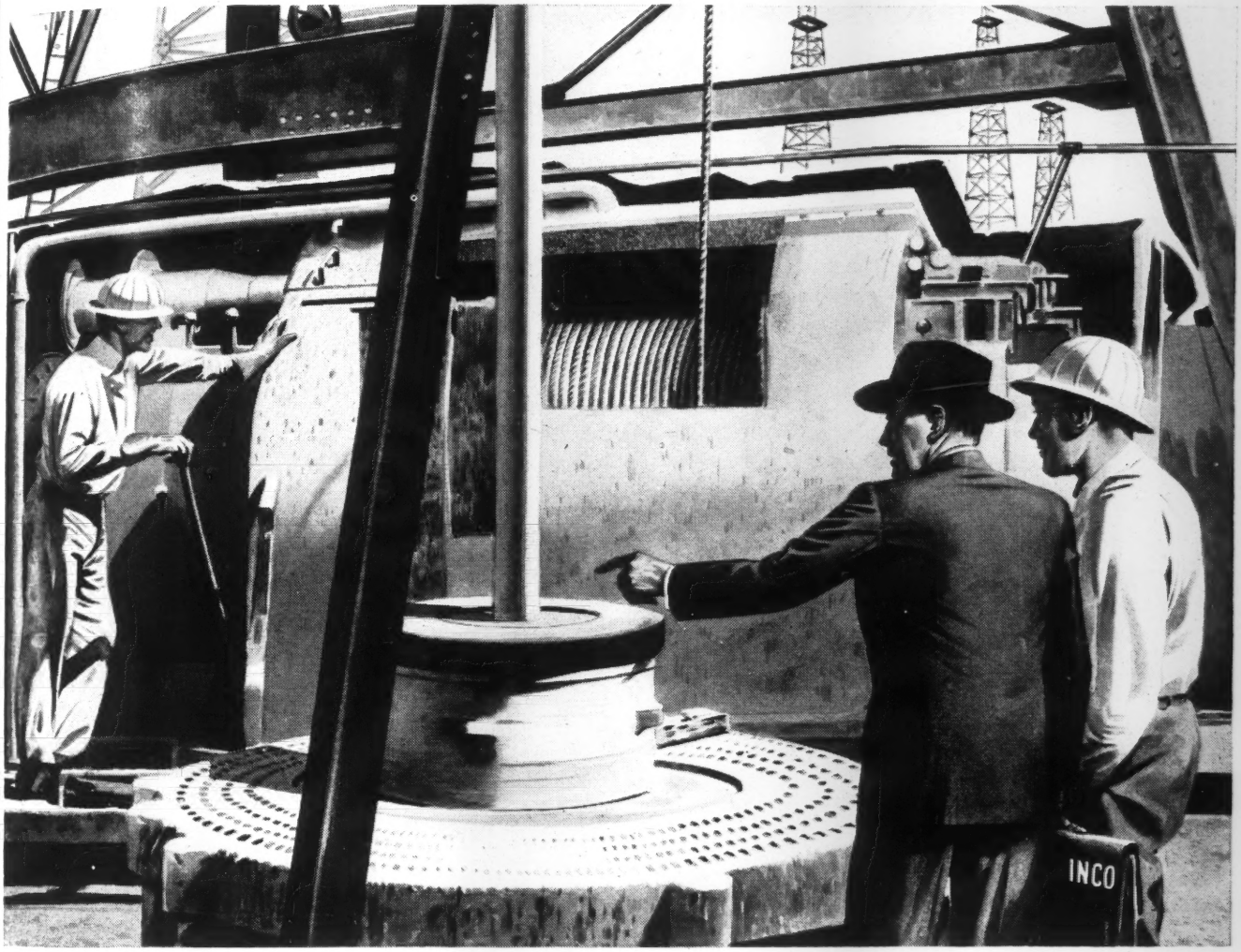
Gasket of Rubber-Sheathed Mesh

ORIGINATED by The Detroit Gasket & Mfg. Co. and produced by The Goodyear Tire & Rubber Co., is a copper-mesh coated with synthetic rubber. This rubber-sheathed mesh has survived exhaustive tests and is now standard equipment for many airplane engines produced in this country. This principle means longer gasket life and decreased oil consumption for postwar civilian automobiles when current warplane demands are lessened. Less than fifteen-thousandths of an inch in thickness, the rubber-sheathed mesh is being supplied by Goodyear for the Detroit Gasket which in turn supplies the complete gaskets. The gaskets are blowout-proof, and are used to seal crankcases of airplane engines to prevent losses of vital oil by seepage or similar causes.

Direct-Current Sensitive Relay



PRIMARILY designed for aircraft service, the Micropositioner being offered by The Barber Colman Co., Rockford, Ill., is a polarized direct-current voltage sensitive relay. It is used for remote positioning of control motors and the control of the air valves, engine cowling flaps, trim tabs, and various similar aircraft installations. The contact tongue is positioned by means of a balanced



NICKEL AIDS THE PETROLEUM INDUSTRY

to KEEP 'EM PRODUCING!

Oil is ammunition. On every battle front, oil is war material number one.

Besides power for ships and subs, planes and tanks, trucks and jeeps, it also provides the basic ingredients for synthetic rubber, toluene for TNT, chemicals, and many other essential war materials.

To meet increased wartime demands for oil, field and pipeline equipment carries heavier loads. Refineries make longer runs at high heats and pressures. Engineers add sub-zero cycles and new catalysts. Equipment is taxed up to and sometimes beyond rated capacity . . . precision equipment that cannot be readily replaced.

Despite emergency schedules, however, that equipment rarely fails. For, since the days when shallow wells were drilled with wooden rigs and kerosene was shipped in oak barrels, oil men have relied largely on stressed parts strengthened and toughened by additions of Nickel.

The oil industry knows many uses for Nickel alloyed materials, from crown blocks to drill bits, from sucker rods to pressure stills. Alone, or in combination with other alloying elements, Nickel helps metals resist corrosion, retard wear and absorb shock overloads. Properly used, a little Nickel goes a long way to insure dependable, uninterrupted operation of production and refining units.

For years the technical staff of International Nickel has been privileged to cooperate with petroleum engineers whose pooled information and "know-how" are now so vital to Victory. To men in all industries who desire assistance in the selection, fabrication and heat treatment of ferrous and non-ferrous metals, INCO engineers and metallurgists offer counsel and data.

New Catalog Index

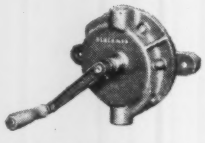
New Catalog C makes it easy for you to get Nickel literature. It gives you capsule synopses of booklets and bulletins on a wide variety of subjects — from industrial applications to metallurgical data and working instructions. Why not send for your copy of Catalog C today?

* *Nickel* *

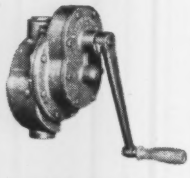
THE INTERNATIONAL NICKEL COMPANY, INC., *67 Wall St., New York 5, N. Y.*

You Are Invited to Consult BLACKMER on SPECIAL ROTARY HAND PUMPS for

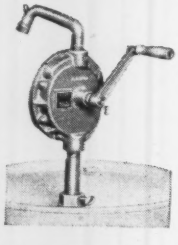
PIPE MOUNTING



WALL MOUNTING



GEARED PUMP



BARREL MOUNTING

LIQUID PROCESSING MACHINERY

•

HYDRAULIC CONTROL EQUIPMENT

•

LIQUID DISPENSING DEVICES

•

MOTOR FUEL HANDLING EQUIPMENT

•

BLACKMER ENGINEERS

are at your service to help with any design problem involving the use of pumps — either hand or power-operated, in capacities from 5 to 750 GPM, pressures up to 300 psi, and temperatures to 600° F.

These pumps are now handling oils, alcohols, chemicals, solvents, syrups, paints, foods, beverages —in fact every type of material from asphalt to butane. The "Bucket Design", swinging vane principle, of Blackmer pumps makes them self-adjusting for wear. Normal capacity is maintained throughout the life of the buckets, which are easily replaced when worn out.

THE PUMP THAT IS SELF-ADJUSTING FOR WEAR "BUCKET DESIGN"

COMPLETE DATA FILE FOR ENGINEERS AND DESIGNERS FREE.

Sign and mail coupon NOW.

To BLACKMER PUMP COMPANY,
1979 Century Ave., Grand Rapids 9, Michigan
Send complete file of engineering data.

Signed .....

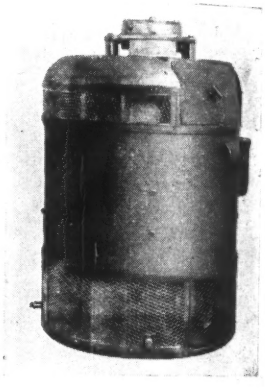
Company .....

Address .....

.....

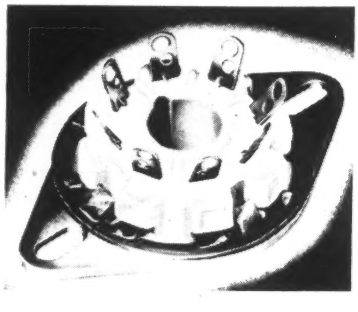
armature. Construction is such that the effect of vibration is reduced to a minimum. Entire operating mechanism is mounted on a bakelite base and enclosed in a transparent lucite case. The sensitivity of the relay is .10 volts, .002 amperes. Weight is 6 ounces. Contact ratings are .5 amperes at 28 volts, noninductive load.

Direct-Current Vertical Motors



RANGING from 40 to 200 horsepower at 1750 revolutions per minute, and in equivalent ratings at other speeds, a new line of direct-current vertical motors has been developed by General Electric Co. Furnished for both constant and adjustable speeds, the new motors are designed for low-thrust, solid-shaft applications on pumps, machine tools, and marine underdeck auxiliaries. These drip-proof motors have convenient fittings on both upper and lower bearings, simplifying lubrication. Provision for escape of excessive grease reduces the possibility of overlubrication. Grease is prevented from entering motor and damaging the commutator and windings by a special bearing housing. The cast-iron conduit box can be arranged for bringing the leads in at the top, bottom, or either side.

Simplified Locking Ring

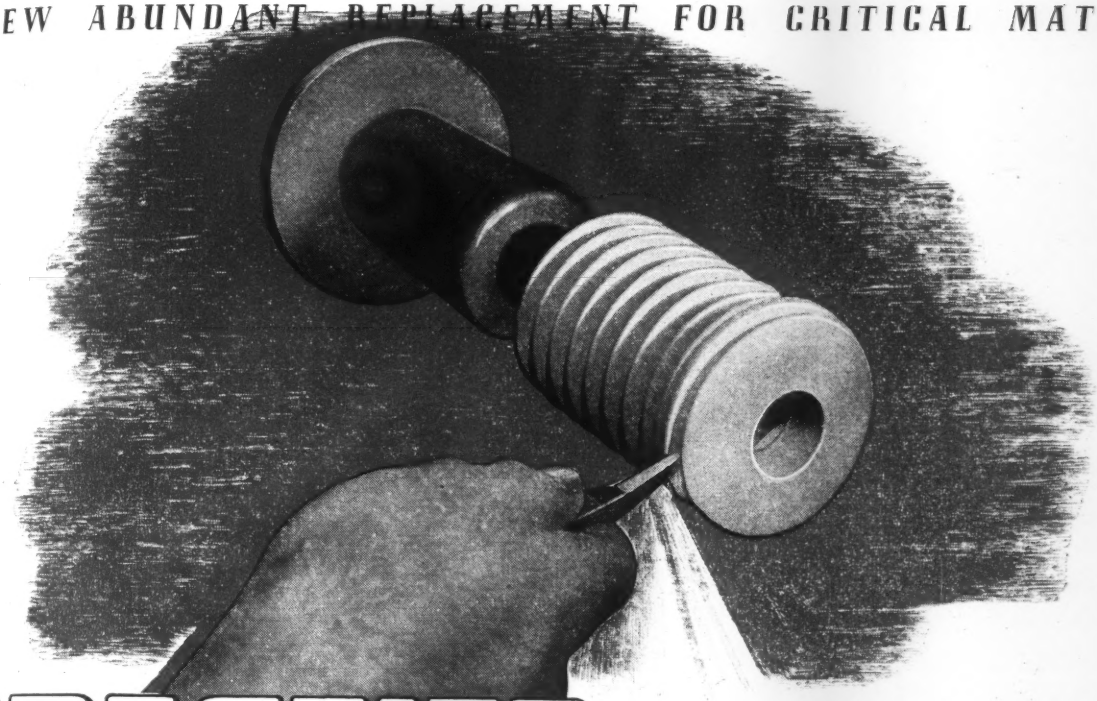


WHILE the new locking ring of A. W. Franklin Mfg. Co., 175 Varick street, New York, was developed for the electronic and radio industries, it can be applied to all industries where parts are locked to parent bodies. A positive lock is assured and unlocking will not damage either the component or the chassis. Operation of the ring is simple and uninvolved; the ring fits between the chassis and the component to be locked, a tool is placed over the component and a one-eighth turn to the right securely locks the component to the chassis. A further one-eighth turn does the unlocking.

Glass for Electrical Insulation

APPLICABLE to a number of glass compositions having widely different characteristics, the Multiform process, a new method of glass fabrication, has been developed by Corning Glass Works, Corning, N. Y. The new process permits the fabrication of shapes not readily pro-

A NEW ABUNDANT REPLACEMENT FOR CRITICAL MATERIALS



PRESTITE—the new pressure-molded ceramic—IS WORKABLE!

Easy workability makes **PRESTITE** a "natural" as a replacement material for many applications. Where metals or other materials often present problems in machining, **PRESTITE** pieces can be turned and shaped on a wheel or lathe, before firing, as easily as clay. Final dimensions can be held to very close tolerances; grinding after firing makes possible extreme precision fits.

Workability is just one of many properties hastening **PRESTITE'S** adoption as a permanent replacement for many materials now critical: **PRESTITE** is impervious to moisture and chemicals except hydrofluoric acid . . . can be cored for intricate internal cavities . . . and can be mass-produced. **PRESTITE** also can be manufactured with several bodies to yield various characteristics such as for applications requiring resistance to unusually high heat shock.

When desired, the modulus of rupture also can be varied from 2.5 to 4.2 and its electrical loss factor reduced far enough so that it may be used as an insulator at ultra-high radio frequencies.

PRESTITE is replacing other materials in an increasing variety of products including sand-blast nozzles, high-speed pump valve seats, brackets and many others.

If the qualities and applications of **PRESTITE** briefly sketched here suggest a clue to your product-problem, Westinghouse will be glad to work with you in solving it.

★ ★ ★

GET THE FACTS ABOUT PRESTITE. New PRESTITE Book shows applications in many fields . . . presents technical working data for designers . . . design suggestions and limitations . . . charts and test results. Write for B-3121. Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa., Dept. 7-N. J-05140

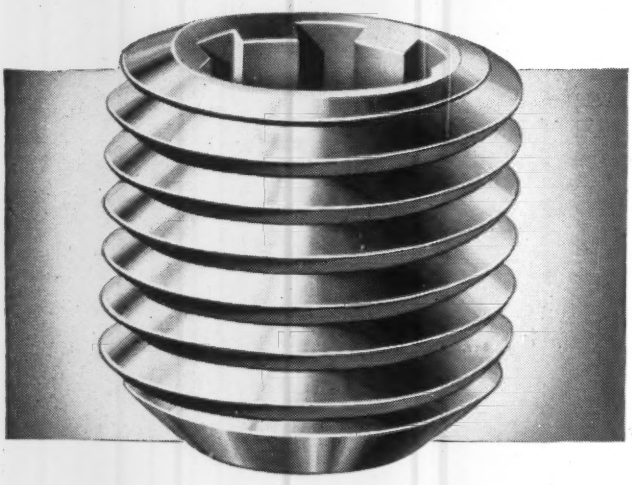
Westinghouse **PRESTITE**

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

The New Pressure-molded Ceramic that can be . . . CORED . . . JOINED TO METAL . . MOLDED to close tolerances . . . designed with METAL INSERTS

Here's What Aircraft Equipment Manufacturers* Are Specifying For Compact, Vibration-Proof Assembly

BRISTO MULTIPLE-SPLINE SOCKET SET SCREWS



SET . . . . FASTER! . . . . EASIER! . . . .TIGHTER!

*SPECIFIED by leading manufacturers of aircraft parts, aerial photographic and electrical communications equipment.

AND HERE'S WHY

1. Splines, like gears, provide faster, easier transmission of rotary power.
2. Splines permit tighter setting, without splitting or rounding out even smallest sized sockets.
3. Tighter setting means maximum resistance to vibration in fast-moving parts.
4. Splines "grip" wrench, make tightening easy in awkward places, prevent wrench slippage.
5. Splines permit removal without damage to socket.

The BRISTOL Company
MILL SUPPLY DIVISION

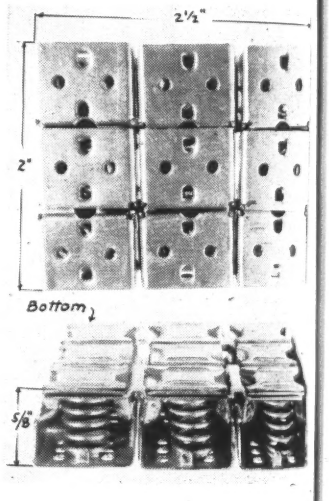
INVESTIGATE!
See THOMAS' REGISTER for Complete Facts, List of Product Applications.

122 BRISTOL ROAD, WATERBURY, CONNECTICUT

duced by conventional methods of glass manufacture. Properties of glass made by this process are essentially the same as when made by ordinary blowing, pressing, or drawing of hot glass, except that it is usually translucent or opaque rather than transparent. Pyrex brand, Multiform processed, is available in sizes from small beads of which there are several thousand to the pound, to large pieces with maximum dimensions up to 15 inches and weighing 25 pounds each or more. Countersunk holes are practicable, and tapped holes are possible within certain limits. Fine pitch threads are less satisfactory than coarse threads, whether external or internal. Types of parts made by this process include coil form end plates, wafer bases, insulators, bushings, tube socket bases, etc.

Springs Absorb Vibration

TO REPLACE rubber and other materials in absorbing vibration and mechanical shock, as in vibration absorbing mounting pads for machine tools, printing presses and other mechanical applications, an all-metal spring cushion device has been introduced by Rande Specialty Co., Hoboken, N. J. The springs consist of three parts: Cap, stud and spring. These are held in place by strips which form the base of the pad and prevent the cells from moving out of position. The studs are placed through the straps, with the springs in the studs.



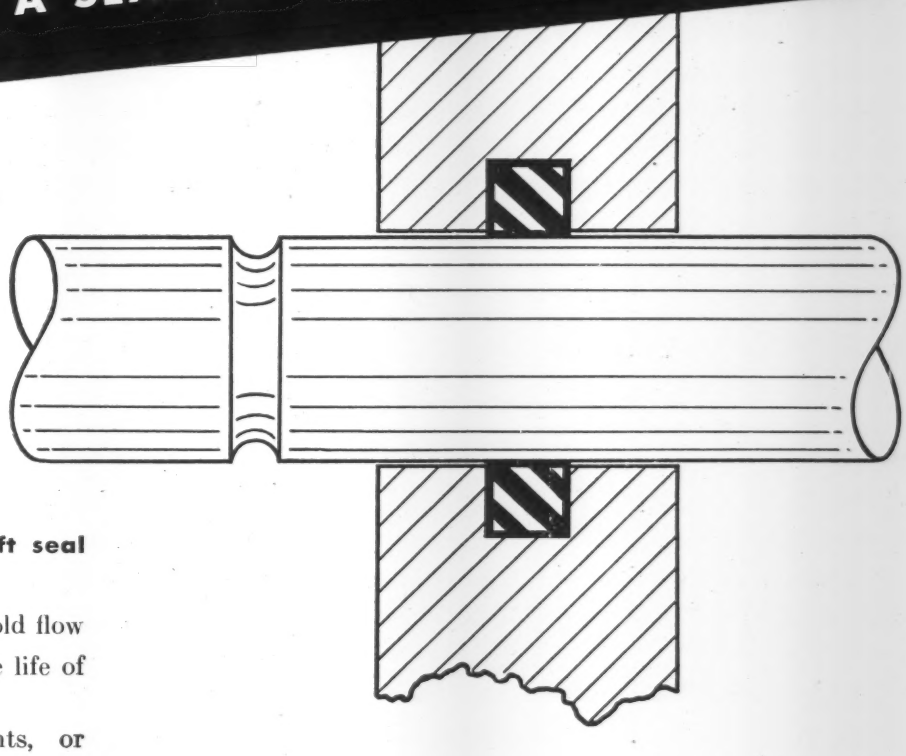
The caps, on top of the springs, are held in place by side lips which are engaged by shoulders on the studs holding the springs firmly in place, yet permitting full floating action at all times. Each spring cell deflects individually under pressure due to uneven surfaces at any particular point. The standard unit of nine cells is capable of sustaining a load of 100 pounds. Under this load the caps are slightly deflected so that the load rides on the springs which are not completely seated until the pressure reaches 125 pounds for each nine-cell unit. The principle employed is that of using a large number of small springs instead of a lesser number of larger ones.

Floating Cam Collars

STRAIGHT, corner, ear and bracket models are included in the floating cam collar line offered in the line of fasteners produced by Camloc Fastener Corp., 420 Lexington avenue, New York. Floating cam collars permit large spotting tolerances. The rivet type cam collars are used for interchangeability with other fasteners and where

(*Continued on Page* 150)

DO YOU HAVE A SEALING PROBLEM LIKE THIS?



REQUIRED: a shaft seal that will . . .

1. Compress without cold flow
2. Stay resilient for the life of the equipment
3. Resist fuels, solvents, or other liquids

HERE'S THE SOLUTION:

Such a set of requirements calls for one of Armstrong's Cork-and-Synthetic-Rubber Compositions—of which there are many types. Selection of the proper type depends upon what liquid the equipment will be called upon to handle and upon shaft speed, operating temperature, and internal pressure.

WHAT THE CORK DOES

The granulated cork in these compositions makes them truly compressible and lastingly resilient. Usually, therefore, the ring is specified slightly over-size in thickness and in O. D., and slightly small in I. D. Results: (1) On assembly, it compresses in all directions *without flow*. (2) In service, it exerts constant pressure on all surfaces for the entire life of the equipment.

The synthetic rubber base (Neoprene or Buna N, for example) provides excellent resistance to the specific liquid involved.

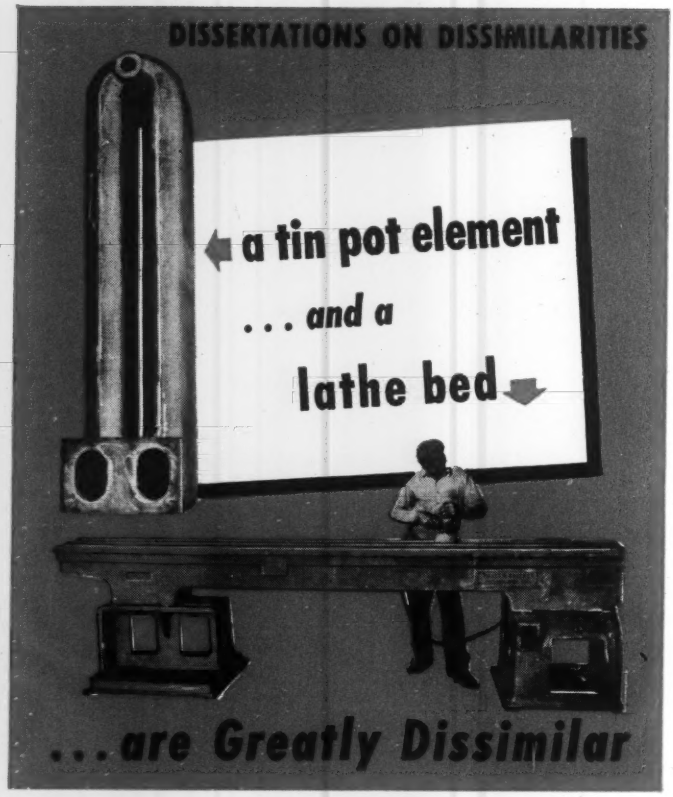
Many perplexing sealing problems have been solved by Armstrong's sealing engineers, who have developed more than fifty sealing materials. (The general types are listed below.) These materials are available in the form of roll goods, sheets, die-cut parts, tapes, ribbon, strips, molded shapes, or extruded rings in various sizes.

FREE CATALOG

Write for your copy of the fact-filled booklet, "Armstrong's Gaskets, Packings, and Seals." And, for sound, unbiased recommendations, send details of your sealing problems to Armstrong Cork Company, Industrial Division, 5109 Arch St., Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Synthetic Rubbers • Cork-and-Synthetic-Rubber Compositions*
Cork Compositions • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork
*FORMERLY "CORPRENE"



. . . yet the characteristics required for both castings are found in ABSCO Meehanite.

Produced under four general classifications, (1) general engineering, (2) heat resisting, (3) wear resisting, and (4) corrosion resisting, ABSCO Meehanite Castings provide high strength, vibration absorption qualities and best machinability. The properties of each of the 21 different types of ABSCO Meehanite can be depended upon because they are obtained by means of strict metallurgical control of metal structure and accurate regulation of raw materials and foundry practice.

Through Selective Processing, a type of ABSCO Meehanite is available to fit the needs of any of these qualities:

1. *Strength, toughness and high damping capacity.*
2. *Ability to stand shock or strain.*
3. *Free machining qualities.*
4. *Density and solidity for pressure castings.*
5. *Heat and corrosion resistance.*
6. *Freedom from warpage that means constant alignment.*
7. *May be heat-treated for higher tensile strengths and increased resistance to wear.*

If you have a problem involving iron, steel, bronze, or other critical material, ask our technicians to explain how ABSCO Meehanite may help you solve it.

3284

AMERICAN
Brake Shoe
COMPANY

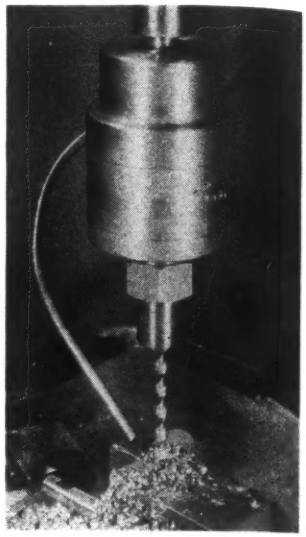
BRAKE SHOE AND CASTINGS DIVISION

230 PARK AVENUE **NEW YORK, N. Y.**

(*Continued from Page* 144)

limited edge clearance prevents company's standard single-hole mounting. Adaptable to metal, plastic and plywood, the collars can be used with both slotted and winghead stud assemblies of same series.

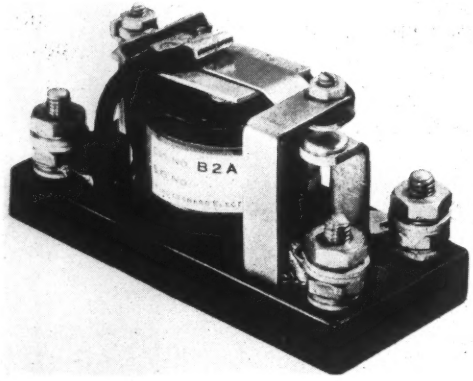
Drilling Assembly Developed



OF INTEREST to designers will be the new driller introduced by The Bastian-Blessing Co., 4203 Peterson avenue, Chicago. Use of the driller, it is reported, greatly increases production, and it can be built into standard drilling machines. It may be operated at handbook cutting speed and feed rates with ordinary drills; and in drilling unusually deep holes in some materials, the drilling time may be reduced by about one-half. Holes that are deeper than five diameters of the drill may readily be made. Small uniform chips formed by up-and-down motion of the drill clear the drill flutes easily, and surplus coolant washes the chips away. This keeps the drill cool and lengthens its life. The drills can be used two or three times as long as usual without sharpening.

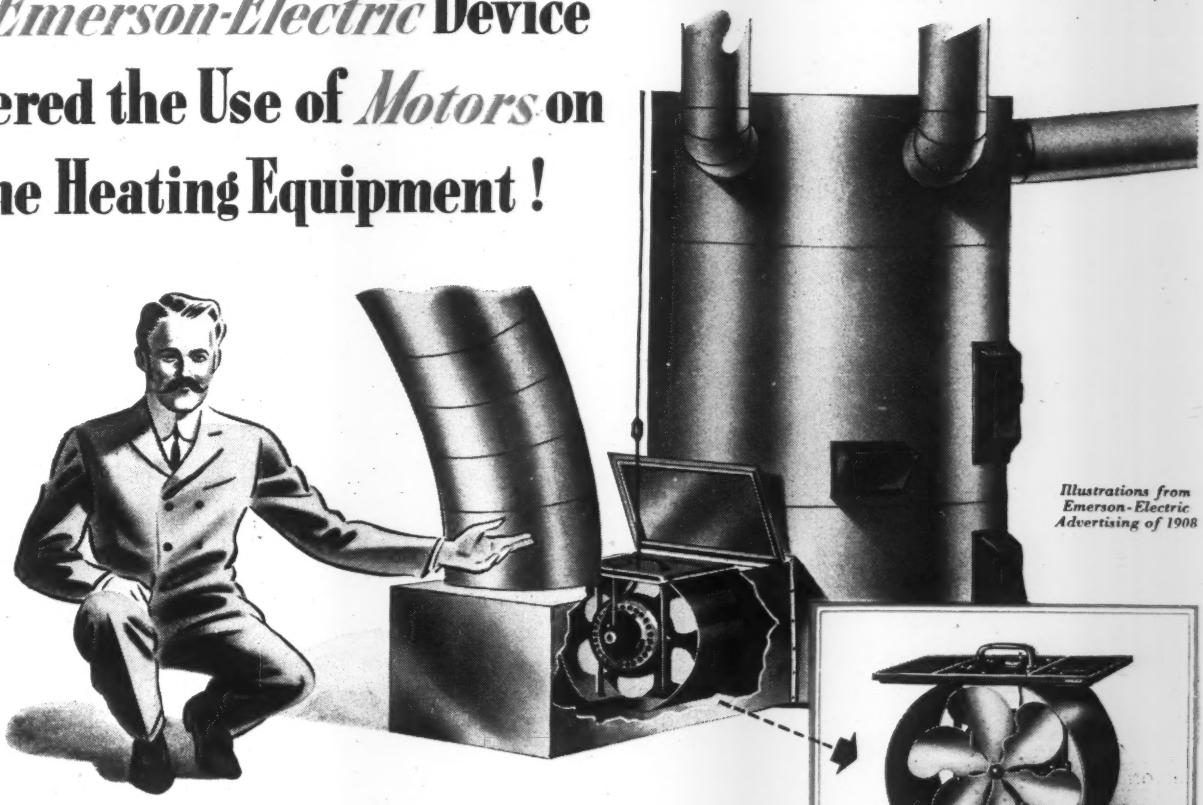
Aircraft Power-Circuit Relay

DESIGNED particularly for aircraft power circuits, the Ward Leonard relay will perform at high values of acceleration of gravity and also under conditions of



vibration and shock. Armature and contact assembly are built to retain either position under these conditions. Normally open, single-pole contacts are rated 25 amperes at

This *Emerson-Electric* Device Pioneered the Use of *Motors* on Home Heating Equipment!



Illustrations from Emerson-Electric Advertising of 1908

Since 1908—when this furnace blower was introduced—a vast new industry has contributed to the raising of American living standards.

Thanks to the ingenuity and progressiveness of heating equipment manufacturers, the people of America will be warmer and healthier next winter than any nation on earth—despite the necessity for fuel conservation.

Since this pioneering idea of a furnace blower was introduced, 35 years ago, the industry has advanced by tremendous strides, using electric motors for many purposes.

All through the years, Emerson-Electric has kept pace, designing and producing precision-built motors for numerous types of mechanical-firing and air-moving heating units. Other new and startling developments are in waiting for the home of the future.

"After Victory", manufacturers of heating equipment will again confidently power their units with Emerson-Electric motors, based on the latest conceptions of design, construction and efficiency.

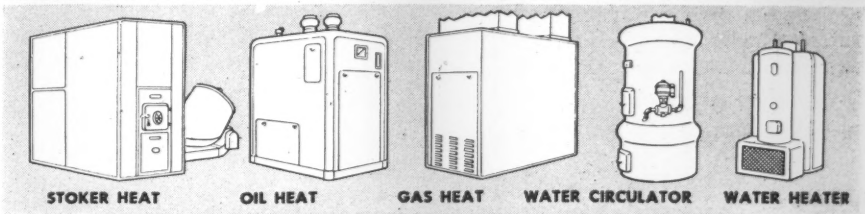
CLOSE UP OF BLOWER
(Blade Side)

This fan-type blower was a logical adaptation of the then time-tested Emerson-Electric fan. Installed in return air duct of the furnace, it supplemented the inefficient gravity method of distributing warm air to all parts of the home.

Store Solid Fuel Now!

THE EMERSON ELECTRIC MANUFACTURING COMPANY
SAINT LOUIS
Branches: New York • Detroit
Chicago • Los Angeles • Davenport

Emerson-Electric Motors in Service Help Guard the Nation's Health



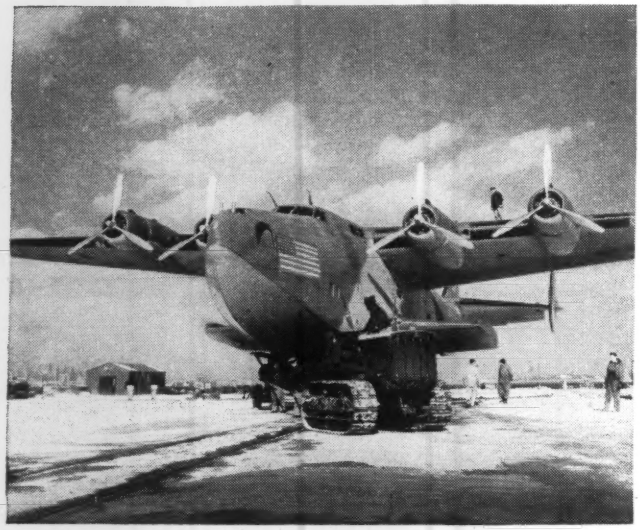
Motor-driven Oil Burners and Stokers for Boilers and Winter Air Conditioning Units. Motor-driven Blowers for Coal, Gas and Oil-fired Winter Air Conditioning Units. Motor-driven Hot Water Circulators—Motor-driven Oil Burner Water Heaters.

331

EMERSON ELECTRIC

MOTORS • FANS • APPLIANCES • A. C. ARC WELDERS

HAIRLINE PRECISION for Air-Line Duty!



★ Though they occupy only a fraction of airplane space, WILCO Contacts and Thermometals mean much to precision flight.

★ Either paired with the correct WILCO THERMOMETAL, or used alone, WILCO Aeralloy Aircraft Magneto Contacts are doing their part to assure *smooth* airplane performance through their own unfaltering performance under gruelling conditions in aircraft magnetos.

★ WILCO THERMOMETALS (thermostatic bimetals) are used for engine oil controls, compensation in voltage regulators, and dependable action in other precision instruments.

★ WILCO THERMOMETALS are also used in various instruments for the Army and Navy—and WILCO Electrical Contacts in tank, gun and ship applications.

★ A SINGLE SOURCE OF SUPPLY—WILCO facilities permit manufacturing customers to secure both electrical contacts and thermostatic bimetal from a single source. This is important, for materials from these two groups are frequently used in conjunction, as parts in the same device. The most effective use of one necessitates a knowledge of the other. WILCO sales and engineering representatives are familiar with both Electrical Contact and THERMOMETAL application. Send us your problem for analysis.

WILCO PRODUCTS ARE: *Contacts*—Silver, Platinum, Tungsten, Alloys, Powder Metal. *Thermostatic Metal*—High and Low Temperature with Electrical Resistance from 24 to 530 ohms per sq. mil,-ft. *Precious Metal Collector Rings*—For rotating controls. *Jacketed Wire*—Silver on Steel, Copper, Invar, or other combinations.

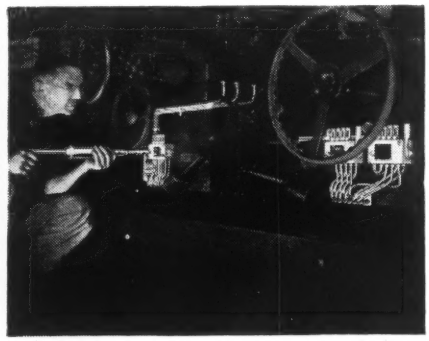
THE H. A. WILSON COMPANY
105 Chestnut St., Newark, N. J.
Branches: Chicago ★ Detroit

WILCO

24 volts direct current, noninductive load, with good characteristics on inductive loads. Contact gap and tail spring tension are adjustable. Bakelite base measures 1⅜ x 3⅛ inches. Two holes are provided in base for mounting. Ward Leonard Electric Co., Mount Vernon, N. Y., furnishes the relay.

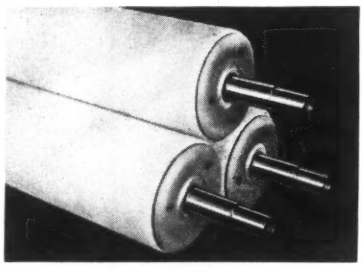
Positive Lubricating System

REGARDLESS of location or condition of bearings, positive lubrication is possible through the improved Multival system of Farval Corp., 3249 East Eightieth street, Cleveland. Oil or grease under pressure is delivered to the distributing blocks by means of a manual or power-operated portable gun which serves as a central pump. Complete Multival equipment consists of the mul-



tiple-valve blocks each serving two to ten bearings, lubricant lines leading to individual points, and suitable fittings to accommodate practically any type of bearing connection. Each measuring valve can be individually adjusted to deliver the exact amount of lubricant required by the bearings it serves. A tell-tale on each valve piston indicates the positive delivery of lubricant to each bearing. With blocks mounted at accessible points on the machine, the operator can lubricate all bearings with complete safety while machine is in full operation.

Cushion-Surface Wood Rolls



FELT coverings for wood rolls produced by Rodney Hunt Machine Co., Orange, N. J., are woven in tubular form, not unlike cotton fire hose. The woven felt provides an ideal cushion on the rolls. Size of such tubular felt jackets is determined by the size of the body on which they are to be mounted. Thickness of felt depends upon how much cushioning effect is desired. Of Shaf-tite construction, the cushion jacket rolls are available in many sizes. The one shown in the illustration is a 6-inch diameter roll on which jackets are about ⅛-inch

WALDES TRUARC presents a significant advance in retaining rings. It spreads or contracts without distortion; always retaining its perfectly fitting circular contour.

For thrust-load fixing, and shaft and housing applications, Waldes Truarc provides distinct advantages over nuts and bolts or wedges and washers... it reduces dimension and weight ...saves material...cuts manufacturing time... simplifies assembly and dis-assembly.

On request, we will gladly furnish samples and full data for your tests.

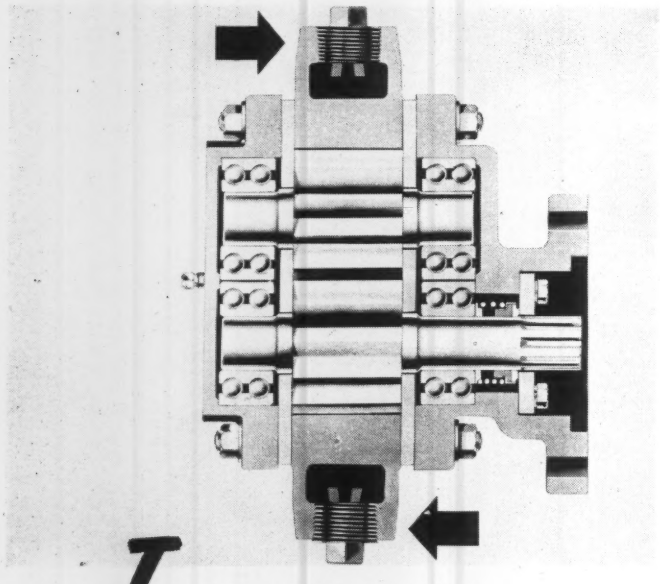
WALDES KOH-I-NOOR-INC.
LONG ISLAND CITY • N. Y.

U. S. Patent
Re 18144

WALDES
TRUARC
RETAINING RING

KEEPING OIL CLEAN

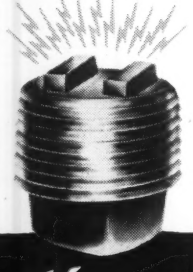
in GAR WOOD Hydraulic Control Units



Two Lisle Magnetic Plugs, placed in the suction line of the pump, keep abrasive metal particles out of the oil in Gar Wood Hydraulic Control Units. Removal of these particles protects the pump against excessive wear and greatly reduces the possibility of fouled valves. ● This is another of the hundreds of applications in which Lisle Magnetic Plugs are used to guard against damage or wear caused by abrasive metal in a lubricant.

Have you considered Lisle Plugs for your product? Write for sample offer.

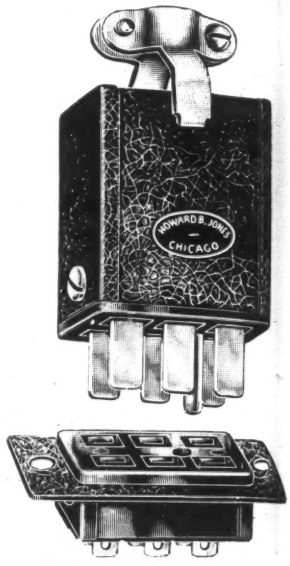
LISLE CORPORATION
Box 1003 Clarinda, Iowa



***Lisle Magnetic* DRAIN PLUGS**

thick. To insure the jackets covering full length of face of roll, they are made extra long and come down over the ends of the roll. In many cases metal end plates are provided, as shown.

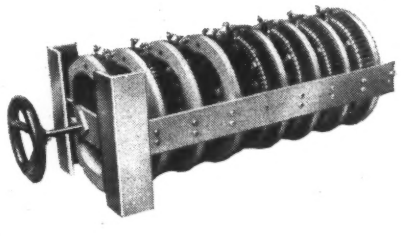
Multicontact Plugs and Sockets



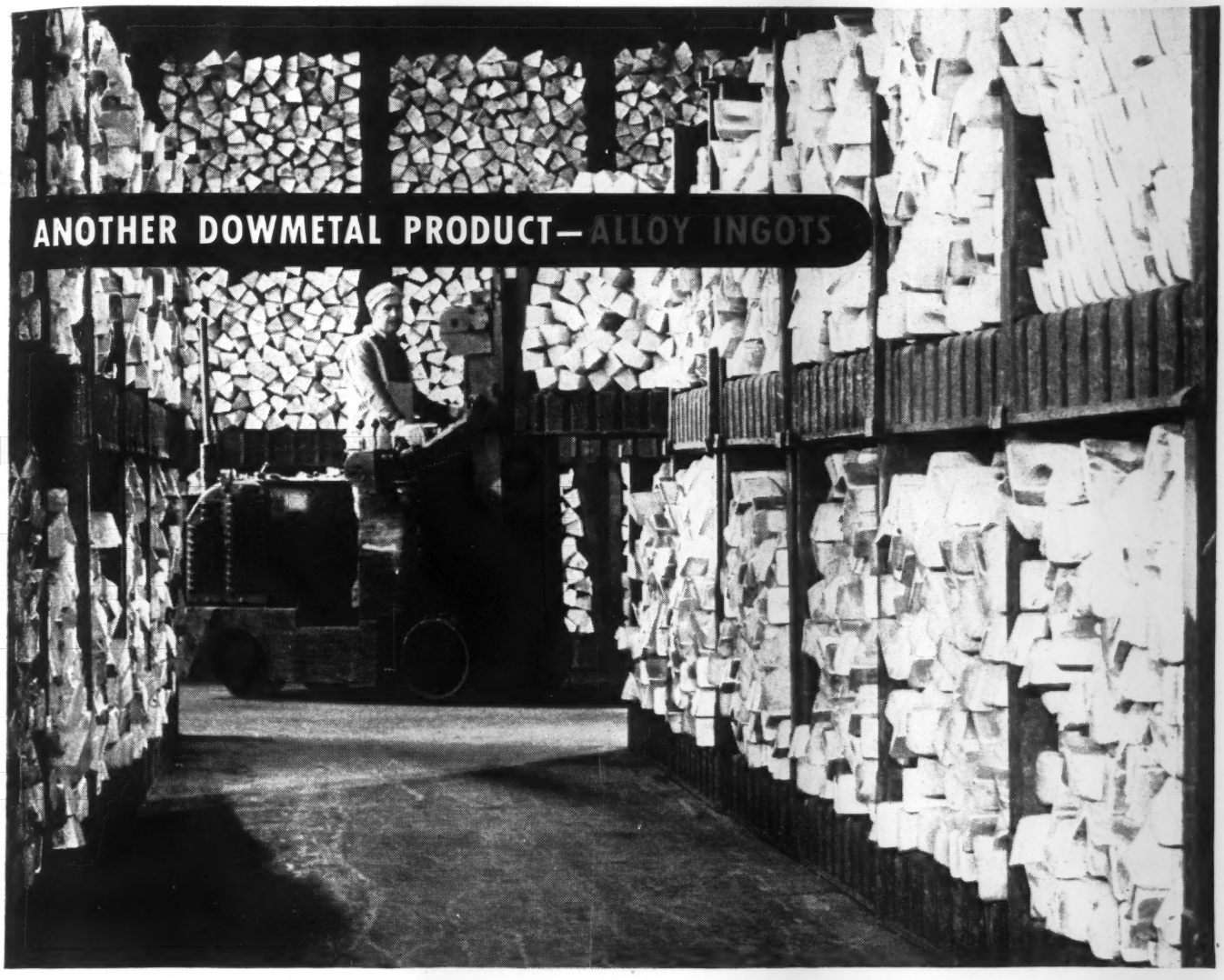
DESIGNED by Howard B. Jones, 2460 West George street, Chicago 18, a new series of multicontact plugs and sockets known as the No. 2400 series are interchangeable with the present No. 400 series. Leakage path is increased and a new type of contact is incorporated in the new series. Bodies are of molded bakelite according to Navy Specifications 17 P 4, having high insulating qualities with maximum strength. Ranges of sizes include 2, 4, 6, 8, 10 and 12 contacts, furnished with either a shallow bracket for flush mounting, deep bracket for recessed mounting or with metal cap with or without cable clamps. As both plug and socket bodies are identical in size, they are interchangeable with either cap or bracket. The entirely new socket contact consists of four individual flexing surfaces making contact with each plug prong. Projections on all four sides of the socket contact, as shown in the illustration, lock it into position when forced into the contact pocket, and prevent any up and down movement. These contacts are of phosphor bronze, silver-plated; the plug contacts are of brass 1/4 x 1/6-inch silver-plated.

Tandem Rheostat Assemblies

TANDEM unit shown in the accompanying illustration consists of eight Model U, 1000-watt, 12-inch diameter rheostats mounted in a steel frame. The rheostat



assemblies are available through Ohmite Mfg. Co., 4835 Flournoy street, Chicago 44. Controlled by a single handwheel, the unit shown is one of the largest of this type



Answering the call for Magnesium Alloys

Twenty-seven years of research and experience go into every Dowmetal magnesium alloy ingot so that you who are entrusted to make vital sand, permanent mold and die castings can forget your alloy problems when you buy ingot from Dow.

All alloy ingots are made under close metallurgical control and furnished in a wide variety of compositions with certified analyses to meet strictest government and industry specifications. Dow also has available a complete line of fluxes and protective agents to meet your every melting problem.

THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

New York • Cleveland • St. Louis • Chicago • Houston • San Francisco
Seattle • Los Angeles

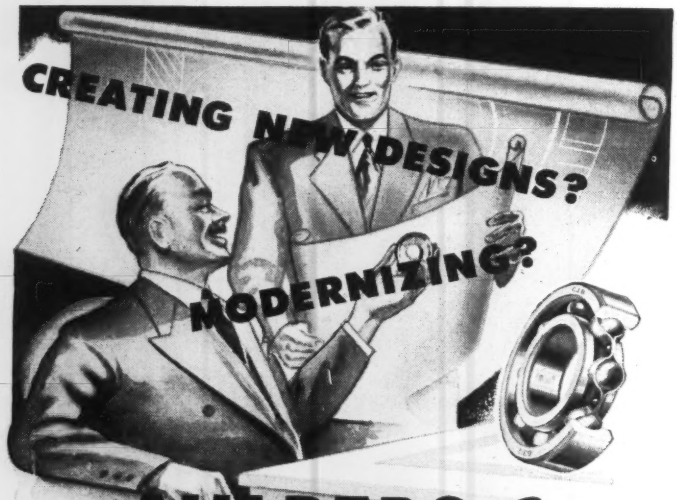
MAGNESIUM

PRODUCER SINCE 1916

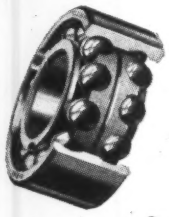
DOWMETAL

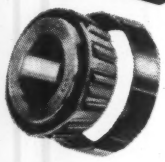
FROM INGOTS TO FINISHED PRODUCTS

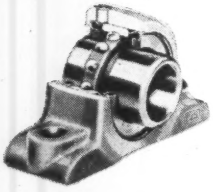
INGOTS • CASTINGS • FORGINGS • SHEET • STRIP • PLATE • EXTRUSIONS

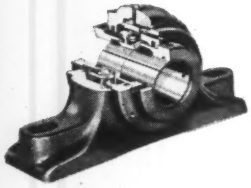


use AHLBERG Service









WAR IS SPEED—the necessity for doing everything faster, and better, and more efficiently. It intensifies the endless conflict against friction. For example, the bombing plane of today uses thousands of anti-friction bearings.

Today, with every energy devoted to Victory, industry wisely plans for tomorrow—studies product designs; studies the swiftly changing markets to adapt products to those ever-changing demands.

Use Ahlberg in your planning. A competent engineering service is at your command. Ahlberg engineers are close students of product trends. They are helping now to create new products, and new designs—are helping industry get ready for the world's vast conversion back to peacetime production.

This kind of thinking is as intensely interesting as it is thoroughly practical. Ahlberg's experience and facilities are available—a letter makes the contact.

Ahlberg Engineering Counsel is available at 26 factory branches.

CJB AHLBERG

AHLBERG BEARING COMPANY

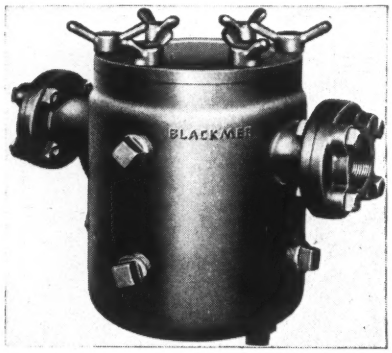
Manufacturers of (CJB) Master Ball Bearings

★ 3017 WEST 47th STREET • CHICAGO, ILL. ★

ever assembled. Although it is unusual in that eight of the largest size rheostats are used, there are many other tandem assemblies made up of two, three or more rheostats ranging in power rating from 25 watts to 1000 watts, and in diameter from 1 9/16 inches to 12 inches. Rheostats in tandem are insulated from each other so that they may be used for simultaneous control of several circuits or phases of a circuit by means of one knob. By means of concentrically located knobs, two rheostats can be separately controlled to conserve panel space or where it may be desired to use one rheostat as a vernier for another. In this type of unit two rheostats are mounted in tandem with shaft of the rear unit extending through the hollow shaft of the front unit. For increased capacity, the front or back units can consist of several rheostats connected together.

Low-Capacity Rotary Pump

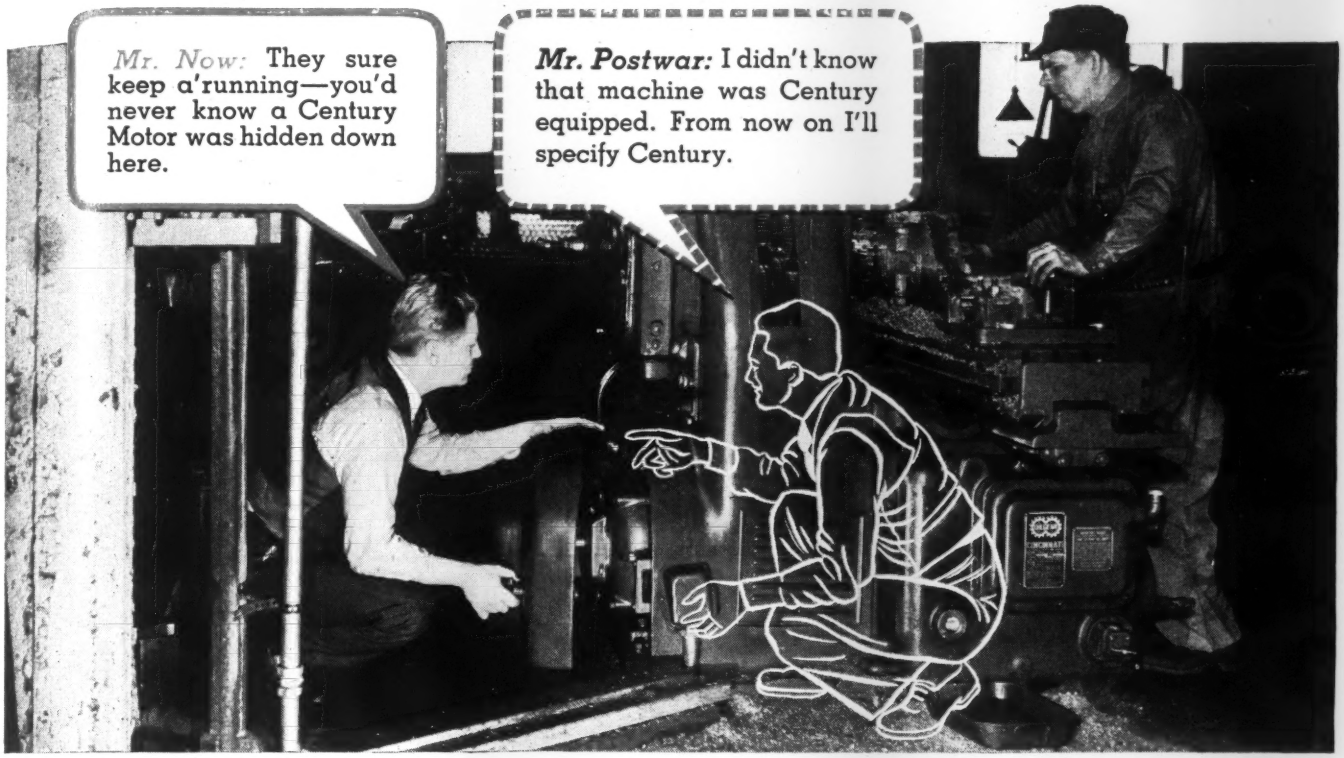
NOW available for general industrial use is a new series of rotary pumps with antifriction bearings which has recently been added to the line of Blackmer Pump Co., Grand Rapids 9, Mich. Capacities range from 10 to 750 gallons per minute, at pressures up to 150 pounds per square inch. The antifriction bearing design has the advantage of reducing power requirements and permitting higher operating pressures. As bearings are in contact with the liquid pumped, the new units are recommended only for handling viscous liquids, or nonviscous liquids having lubricating properties such as oils, molasses, syrups, etc. The pumps are available in all-iron or in bronze-fitted construction, with or less removable liners; also with steam-jacketed heads and in all standard drives including gearhead motor.



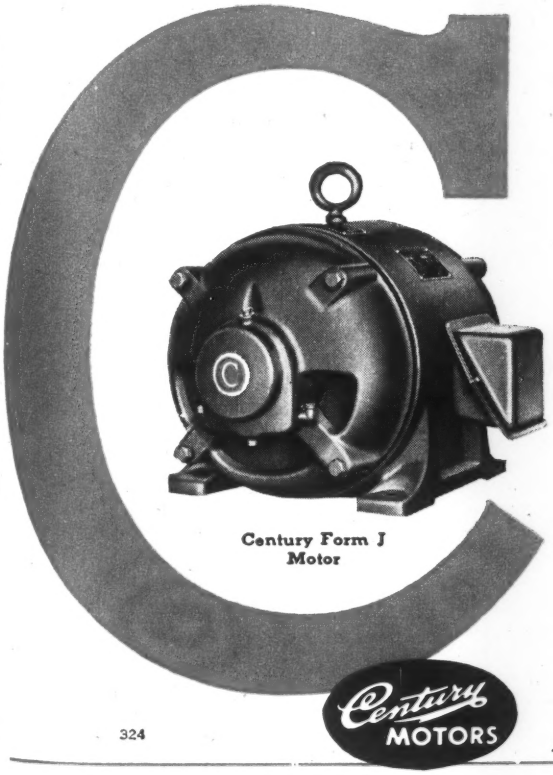
Impregnated Plywood Introduced

RESIN-IMPREGNATED plywood, heated by high-frequency waves and simultaneously compressed under heavy pressure, is available from Pluswood Inc., Oshkosh, Wis. Known as Pluswood, the material is furnished in any desired thickness, in large or small sheets, in natural dark deep brown color, with a wood grain and high gloss finish, and has high density. It is light in weight and is resistant to exposure, and can be sawed, drilled, turned, threaded, milled and tapped. Other characteris-

Take a Look at TOMORROW—*Today!*


Mr. Now: They sure keep a'running—you'd never know a Century Motor was hidden down here.
Mr. Postwar: I didn't know that machine was Century equipped. From now on I'll specify Century.

QUIET AND OFTEN UNSEEN *BUT ALWAYS VITAL!*



Century Form J Motor

Not only on machine tools, but on many widely varied applications, the electric motor may be hidden from sight. Yet, because the machine performance depends to such a large extent upon the motor and its characteristics, it is one of the most vital parts.

In thousands of applications, particularly on machine tools, Century Motors are the unseen, dependable servants of the machine operators. They'll run quietly, continuously, and with an unusual freedom from vibration that contributes much to precision workmanship.

Today, under the rigid demands of Wartime production, Century is developing even finer motors than we have made in over forty years of manufacturing—motors that correctly match the demands of the machine and which are properly protected against surrounding conditions as well.

Remember the importance of the motor, even though unseen — and it will pay you to think of Century in *your* postwar planning.

CENTURY ELECTRIC CO., 1806 Pine St., St. Louis, Mo.
Offices and Stock Points in Principal Cities

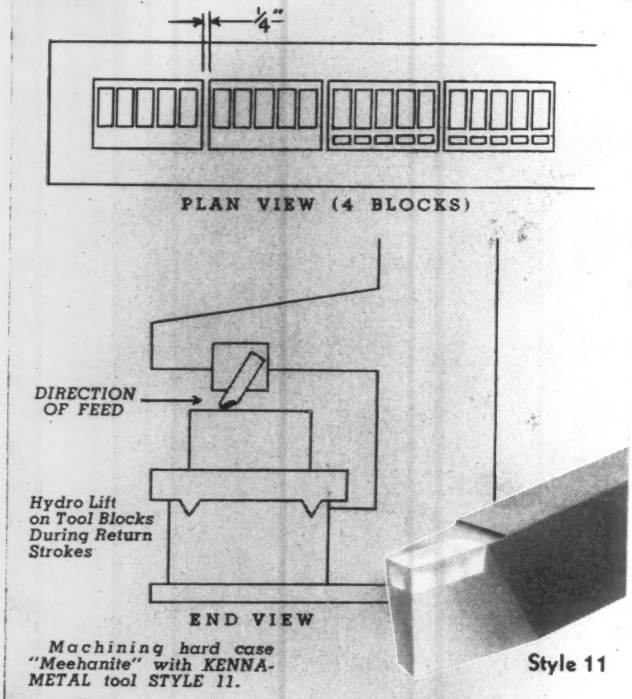
Century MOTORS

324

1/6 to 600 horsepower.

One of the Largest EXCLUSIVE Motor and Generator Manufacturers in the World

Reduce
FLOOR TO FLOOR TIME



Machining hard case "Meehanite" with KENNAMETAL tool STYLE 11.

Use KENNAMETAL
For Difficult Machining

The greater wear resistance of KENNAMETAL tools and their proper use has reduced the floor-to-floor time 50% in this machining of hard cast Meehanite, and decreased the loss of actual operating time caused by the necessity for frequent resharpening ordinary tools.

Planing the bottom surface of Meehanite die blocks, using a .040" feed with a 3/16" to 1/4" depth of cut at a speed of from 75 to 80 ft./min., the cutting time required for one set of 4 blocks with KENNAMETAL was only 4 hours compared to 8 hours with solid high speed tools, which required sharpening after each 5 to 6 passes—KENNAMETAL machined the set completely before grinding was necessary.

KENNAMETAL'S higher rupture strength and greater hardness enable these steel-cutting carbide tools to withstand the extreme shock of interrupted cuts and the pressure of heavy feeds on steel having a hardness up to 550 Brinell.

Write for your KENNAMETAL Tool Manual which will help you choose the proper tool for your particular machining problem.

KENNAMETAL *Inc.*
146 LLOYD AVE., LATROBE, PA.
Trade Mark Reg. U. S. Pat. Off.
Foreign Sales: U. S. STEEL EXPORT CO., 30 Church St., New York (Exclusive of Canada and Great Britain)

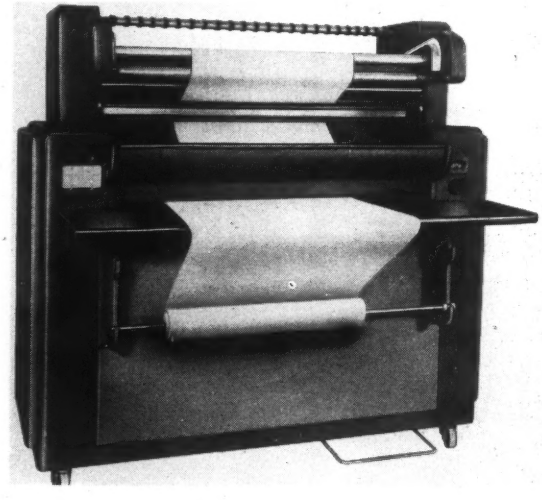
tics include nonflammability, high resistance to decay, acids, alcoholic mixtures and other organic liquids. Specific gravity is 1.3-1.4; tensile strength (parallel laminated in fiber direction), 32-40,000 pounds per square inch, and compressive strength, 20-28,000 pounds per square inch. Impact strength is (Izod), 6-8 pounds per inch of notch. The material at the present time has been used as exhaust and blower fan blades, and in boat-building, aircraft and automotive industries.

Rubber Substitute Offered

MADE from vegetable oils and without use of critical materials, Kem-Pol is offered by Sherwin Williams Co., 101 Prospect avenue, Northwest, Cleveland, as a substitute, replacement or extender for natural, synthetic and reclaimed rubber for conditions where low tensile strength and elongation are permissible. The material is available in various grades. No. 11 is the most viscous of the untreated polymers. It is ruby red rather than amber by transmitted light, as are the other grades, and is soluble with difficulty, if at all, in aromatic hydrocarbons. This grade can be emulsified, and its preferred use is in the preparation of mill stocks and molded goods, although it may be used also in adhesives. No. 11-41 MP is based on No. 11 and represents this grade in a precured state. The 11-41 MP is a dry, cream to tan-colored sheet, which has only a slight tack, and differs from the other polymers in that it may be worked directly on the rubber mill, without pretreatment.

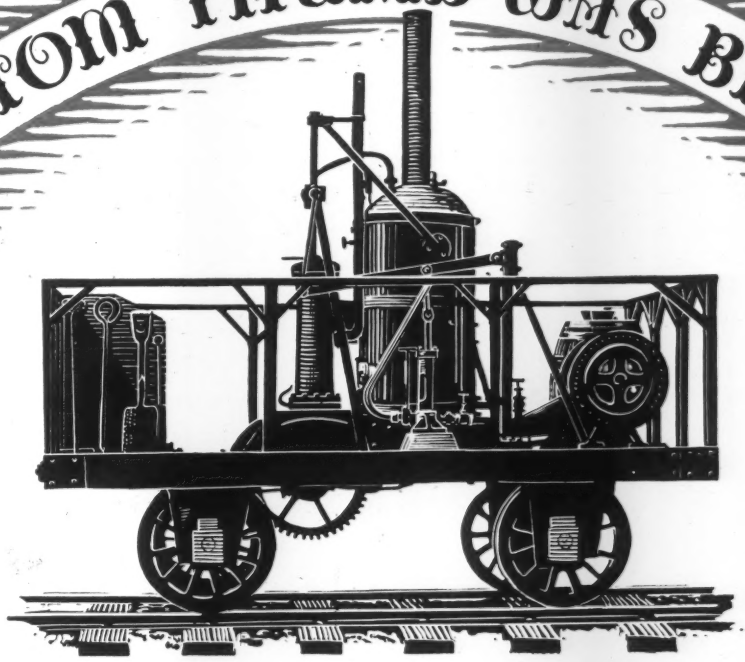
Engineering Dept. Equipment

TO SPEED up war production plans and specifications Charles Bruning Co. Inc., 4700 West Montrose avenue, Chicago, has developed a new high-speed printer utilizing a new mercury vapor quartz lamp developed by Hanovia Chemical & Mfg. Co., Newark, N. J. The new



printer will produce black and white prints of engineering plans 100 times faster than through the use of natural light. Good black and white prints or blueprint from new ink tracings on cloth, can be obtained at speeds 20 to 2

WHEN TOM THUMB WAS BIG TIME



First railroad locomotive in the United States. The "Tom Thumb," built in 1829-30, was successfully operated by the Baltimore and Ohio Railroad.

Back in the days of Tom Thumb, machine production was simple.

Good mechanics, usually blacksmiths, with "cut and fit" methods could make you a boiler or a pump — such as it was — almost while you waited.

Today, specialized engineering, competent machine designing, the development of tools, jigs and fixtures, essential production facilities, planned production and centralized distribution are all essential to successful selling.

Universal Engineering offers just such a service — engineering, designing, production — for engineering or sales companies needing manufacturing help. Truly a service to fit your needs.

Our facilities are complete. Our location and labor supply ideal. Our scope of operation broad. As an example, we are now producing a wide line of machinery from small, close tolerance airplane instruments to massive 16-ton crushing plants.

Check Universal service first! Let one of our trained engineers consult with you on your manufacturing needs for tomorrow.

UNIVERSAL ENGINEERING CORP.

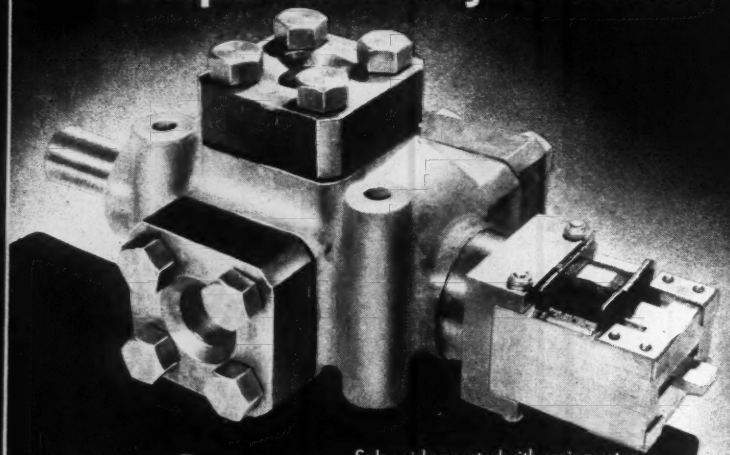
618 C Ave. West — CEDAR RAPIDS, IOWA

SPECIFY HYDRO-POWER

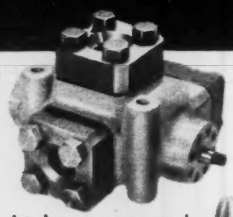
Solenoid Operated

HYDRAULIC PISTON VALVES

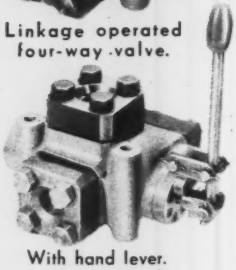
Compact and Easy to Install



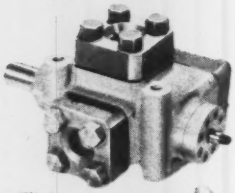
Solenoid operated with spring return.



Linkage operated four-way valve.



With hand lever.



With spring return.

Hand-lever and spring return.

Designed especially for heavy duty hydraulic service, this line of HYDRO-POWER four-way operating valves requires a minimum of power for shifting. Four-bolt, weld-type flanges make piping easy and eliminate leakage. Valves can also be supplied for linkage or hand lever operation as illustrated. Other HYDRO-POWER piston type operating valves are available; two-way or four-way styles, with flanged or screwed connections. Specify HYDRO-POWER operating valves for dependable hydraulic pressure service. Write for specifications and prices.

HYDRO-POWER SYSTEMS, INC.

Division of The Hydraulic Press Mfg Company

Mount Gilead, Ohio, U. S. A.

hydro power

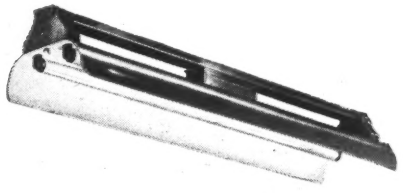
HYDRO-POWER

HYDRAULIC PUMPS AND CONTROLS - VALVES - CYLINDER AND RAM ASSEMBLIES - POWER UNITS - SYSTEMS - SPECIAL HYDRAULIC EQUIPMENT.

feet per minute. The new light tube is equivalent to six to eight powerful carbon arc lamps. It is a high-pressure mercury arc in an enclosure of fused quartz. In addition to increased speed in exposing prints, the lamp requires less power than previous models.

New Fluorescent Fixtures

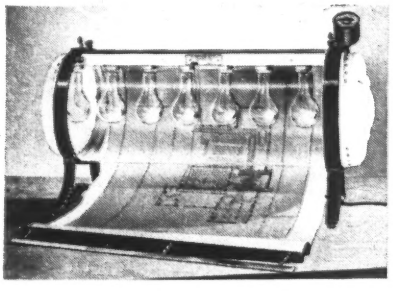
AN ENTIRELY new idea in fluorescent lighting fixture design has been developed by Mitchell Mfg. Co., 2525 North Clybourn avenue, Chicago. The 40-watt units contain less than 3 pounds of steel per fixture, and the 100-watt ones less than 4 pounds. A wide range of accessories and fittings for every method of mounting or ranging to fit lighting situations in drafting rooms, for instance, are available. Each model can be used for both



individual and continuous row lighting, for surface or suspension mounting. The new type wireway channel simplifies problems of wiring and mounting for continuous rows. Reflectors are of nonmetallic composition, known as Lumenite, which is moisture and high heat resistant, and noncorrosive. Glossy baked enamel finish gives high reflection factor. The new fluorescent lighting is available in four models, for individual or continuous row mounting: 2 and 3-light units using 40-watt lamps, 2-light unit using 100-watt lamps, and a 2-section unit for four 100-watt lamps operating with one ballast.

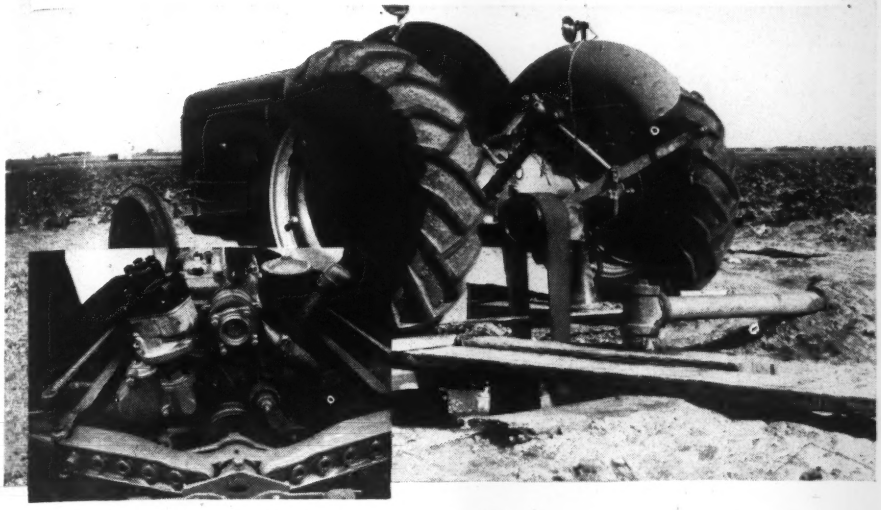
Machine Prints, Copies, Dries

WITH the capacity to make blueprints, black-and-white prints or authentic photo copies up to 24 x 36 inches, and at the same time function as a photo print dryer, the new Victoray Products Co. printing and copying

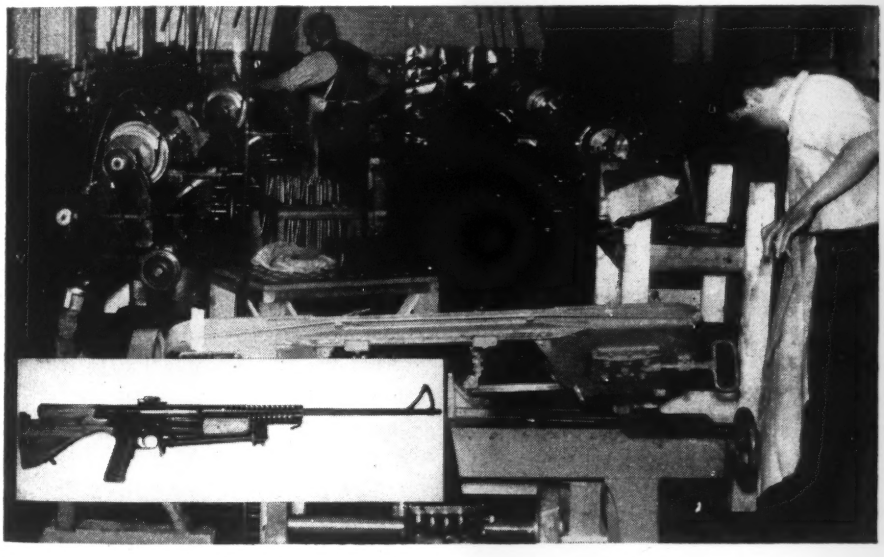


machine is finding its way into engineering departments. The company is located at 123 North Wacker drive, Chicago. Using eight standard incandescent bulbs, the machine employs no transformers, photo flood, mercury or arc lamps.

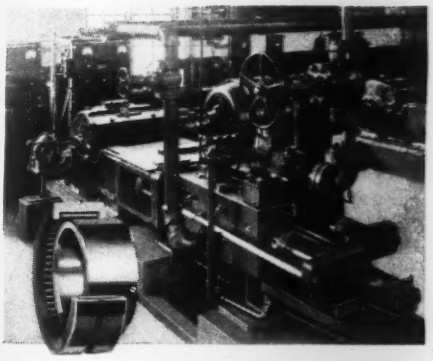
IN THE NEWS
WITH TORRINGTON—BANTAM



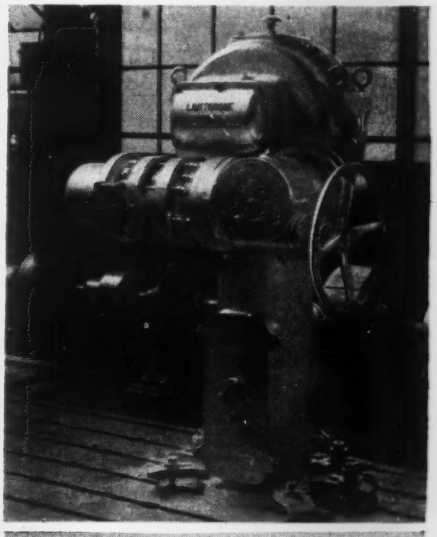
PUMPING WATER FOR IRRIGATION is just another job to the versatile Ford-Ferguson Tractor produced by Harry Ferguson, Inc. So that the fan will spin at its normal cooling rate, an "idler pulley" provides a ready adjustment for fan belt tension. Because of their high load capacity, efficient lubrication and low coefficient of friction, NCS Needle Bearings have been employed on the "idler pulley "for this frequently long-sustained job of "idler pulley" operation.

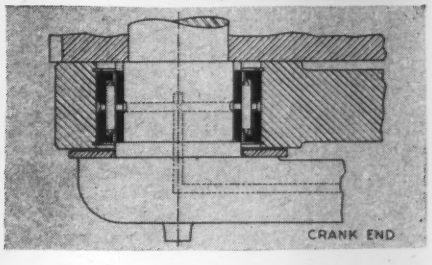


UTMOST PRECISION is required in the manufacture of .30 caliber Johnson Light Machine Guns. To produce these modern weapons of war, Johnson Automatics, Incorporated uses special precision equipment in which Needle Bearings are installed. These Needle Bearings were selected because of their unusually high unit capacity and ready adaptability to many machine tool operations.



WARTIME OUTPUT OF PLASTIC MATERIALS is aided by these large pumps built by the Worthington Pump and Machinery Corporation. Here again heavy-duty NCS Needle Bearings in the wrist pins contribute to the high operating efficiency of these pumps, which are designed for a flow of 70 GPM pumped at 2000 pounds working pressure.



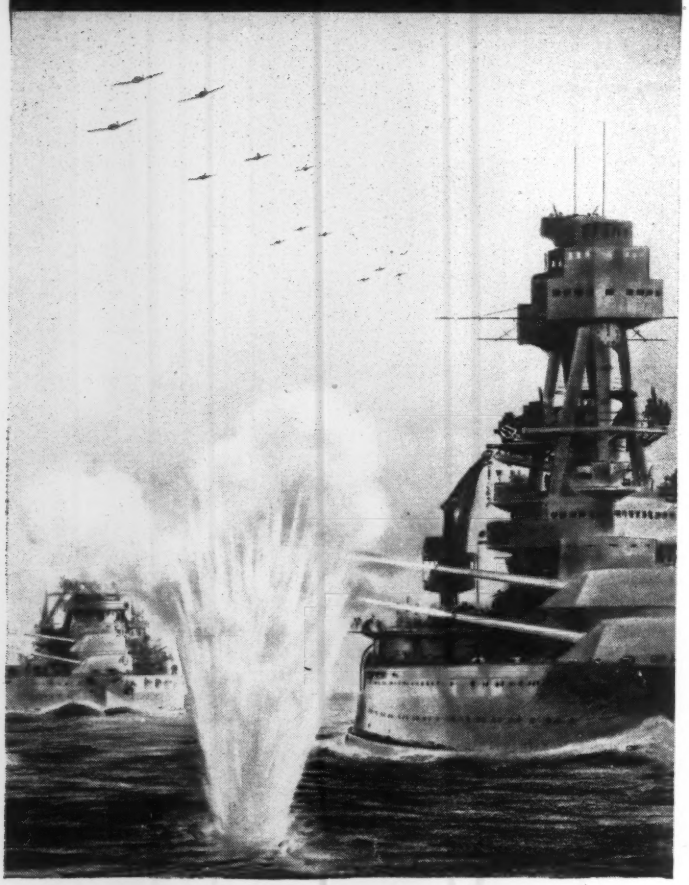


HIGH LOAD CAPACITY AND SMALL SIZE, which permit the use of smaller stressed parts than would otherwise be possible, are reasons given by Philadelphia Gear Works, Inc. for the application of NCS Needle Bearings in these valve controls. Used on the crank pins, these unusual anti-friction bearings permit the use of a one-piece, rather than a split connecting rod.

A COMPLETE LINE of needle and standard anti-friction bearings—all types, for all purposes—is available from Torrington-Bantam, as well as special types and custom-designed bearings for new and unusual applications. In addition, the unbiased counsel of engineers experienced in the selection and design of bearings for every requirement is offered by Torrington-Bantam without obligation to help you meet both today's and tomorrow's needs. For assistance in the solution of *your* bearing problems, TURN TO TORRINGTON.

ARMY NAVY
TORRINGTON BEARINGS
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL
THE TORRINGTON COMPANY · BANTAM BEARINGS DIVISION
SOUTH BEND 21, INDIANA

They'll let 'em have it



. . . if we do our part back home!

Our Navy will give 'em the works, if we'll give 'em all we've got back here in America. That means working a *full* week *every* week . . . it means no unnecessary driving . . . it means conserving materials . . . and it means that we must all buy War Bonds regularly. Let's all do our part today and every day until the war is won!

THE GARLOCK PACKING COMPANY, PALMYRA, NEW YORK
Manufacturers of GARLOCK Packings, Gaskets and KLOZURE Oil Seals
In Canada: The Garlock Packing Company of Canada Limited, Montreal, Que.

GARLOCK

PROFESSIONAL VIEWPOINTS

" . . . basic value of standardization"

To the Editor:

I have read with much interest Colin Carmichael's article "Specify Standard Parts" in the July, 1943, issue of MACHINE DESIGN.

Mr. Carmichael has brought out effectively the basic value of standardization as employed by progressive manufacturers. That is, to provide interchangeability of components and uniformity of dimensions that will prevent multiplicity of parts as well as to eliminate as far as possible short runs, thus reducing inventories in the manufacturers' warehouses and in their customers' stocks. Such standardization does not interfere with ingenuity or make for conventionality in appearance of the finished product.

Standardization to the extent necessary to provide interchangeability of components in fighting equipment has greatly simplified and expedited production.

You have made a definite contribution to the War Production Board's conservation program through the publication of this article, as well as in many other ways.

—HOWARD COONLEY, *Director*
Conservation Division
War Production Board

" . . . standards for drawing sheets"

To the Editor:

I read with interest the suggestions by Frank P. Kuhl (MACHINE DESIGN, April 1943, Page 140) to standardize paper sizes based on the final size 11 x 7½ inches. I would like to remark that quite recently in this country and in Australia suggestions were made to standardize the drawing paper size 13½ x 9½ inches, whereas in countries with the metric system the drawing paper sizes are based on the size 210 x 297 millimeters, approximately 8¼ x 11½ inches. It probably would be worthwhile to consider after the war an international standardization of drawing paper sizes since the above suggested sizes are based all on the ratio 1 to $\sqrt{2}$ as the relation between short side and long side and only the actual dimensions differ somewhat. Taking, for instance, the metric dimensions as a base the suggested American shape differs by —½-inch for the long side and —¾-inch for the short, whereas the British-Australian shape differs by +2 and +1¼ inches respectively.

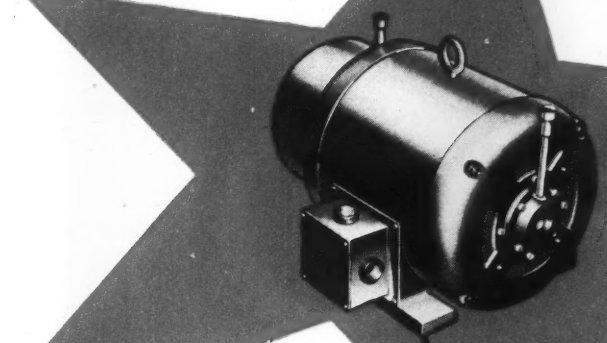
—P. GRODZINSKI
London

Drawing sheets in this country generally are standardized on the basic 8½ x 11-inch size sheet and multiples thereof, to facilitate folding and filing in letter-size files. This is also in accordance with the proposed revised standard of the American Standards Association. Mr. Kuhl's proposal provided for economical cutting from standard-width paper rolls.—ED.

IN THE TIGHT SPOTS IT'S A STAR

To meet special market conditions, American Can engaged STAR to accommodate a 25-cycle motor to a 60-cycle space in their high speed can-closing machine. This meant fitting the horsepower required to a space of smaller diameter. STAR—as usual—*engineered* this ticklish "tight spot" successfully through its unique welding process without special molds or castings. Just another example of Star performance which combines the flexibility of specialized application and engineering with standardized design.

Star Electric Motor Company
Bloomfield, N. J.

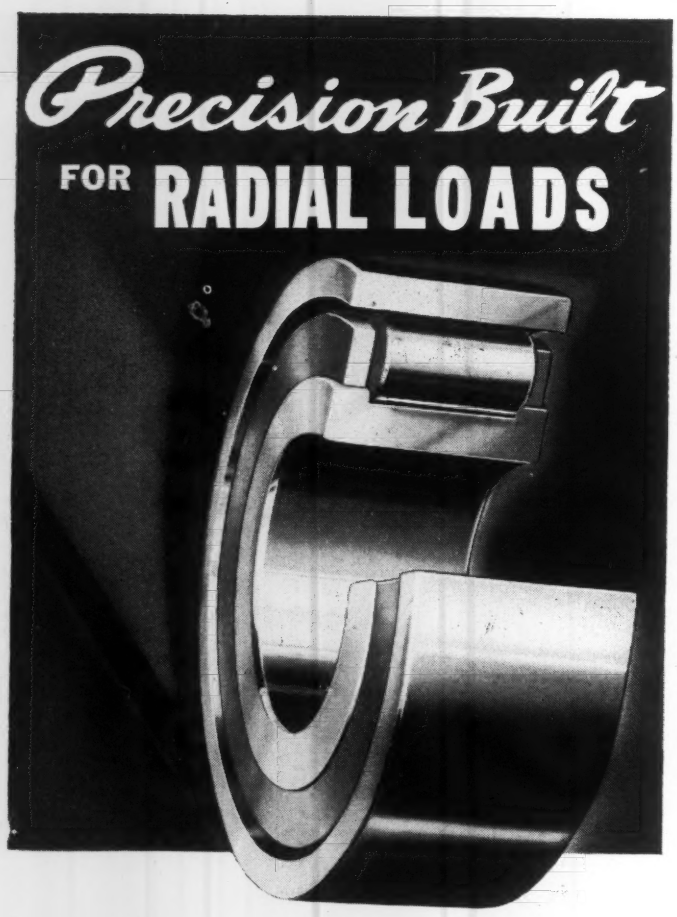


For 33 years, Star Motors have provided a complete line of standard as well as special motors—in sizes from ½ to 200 H.P. Today they provide dependable power for many applications. Write us about your requirements.

POWER *PACKAGED* AS YOU NEED IT

ARMY E NAVY

STAR MOTORS



AMERICAN RADIAL ROLLER BEARINGS are *precision built* for almost every heavy-duty bearing application where the load is radial. Use of AMERICANS in heavy machinery lowers maintenance costs and increases the performance-life of vital equipment. AMERICAN RADIAL ROLLER BEARINGS are readily adaptable because the outer race is removable for easy assembly. Rugged durability and long-life are assured by special heat-treated alloy steel. Constant inspection and precision tests make for absolute accuracy, and smooth, quiet performance.

AMERICAN RADIAL ROLLER BEARINGS are made in 5 styles, 4 S.A.E. series and 85 sizes. Special designs to your requirements are also available. Write today.

AMERICAN ROLLER BEARING CO.
PITTSBURGH, PENNSYLVANIA

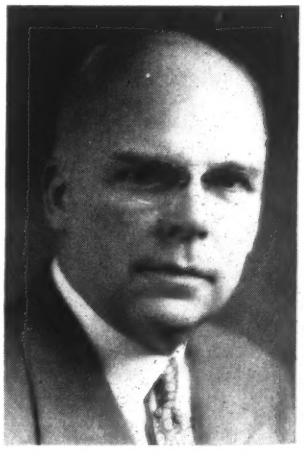
Pacific Coast Office:
1718 S. Flower St., Los Angeles, Calif.

HEAVY DUTY

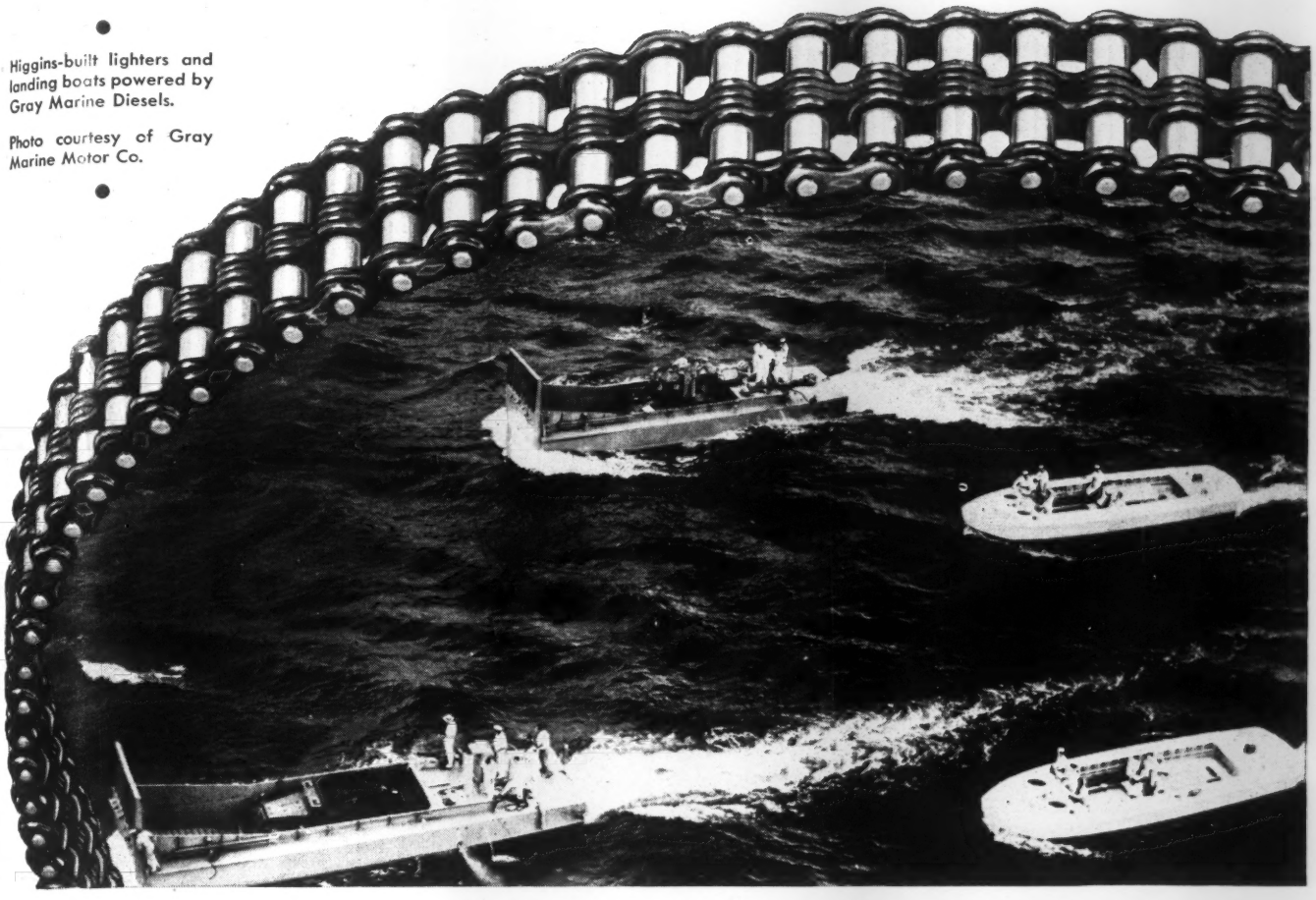
AMERICAN HEAVY-DUTY ROLLER BEARINGS

MEN OF MACHINES

ACTING as executive director of a new marine division plant at Reliance Electric & Engineering Co. for the past ten months, Fred E. Harrell, assistant chief engineer, has been appointed chief engineer of the company. His special assignment in the new marine division has been carried out with marked success, the division now being in volume production of special-purpose electric motors for the Navy and Merchant Marine. In the meantime, increased demands on the company's engineering staff made it imperative that Mr. Harrell resume his responsibilities in the engineering department. Mr. Harrell came to the company in 1924 after graduating in electrical engineering from Purdue university. In 1927 he was transferred from sales engineering in the company's Chicago office to general engineering in Cleveland. Since then he has had charge of the drafting room, of alternating-current design work, and since 1924 has been assistant chief engineer. He is a fellow of the American Institute of Electrical Engineers and chairman of the Institute's committee on electrical machinery.



NOMINEE for president of The American Society of Mechanical Engineers, Robert M. Gates, is a fellow of the society, and is president and director of the Air Preheater Corp. Born in Iowa, Mr. Gates is a graduate of Purdue university, receiving a degree of Bachelor of Science in mechanical engineering in 1907. Upon graduation he practiced as a consulting engineer and later became assistant to the president of Thew Steam Shovel



Higgins-built lighters and landing boats powered by Gray Marine Diesels.

Photo courtesy of Gray Marine Motor Co.

DIAMOND DRIVES

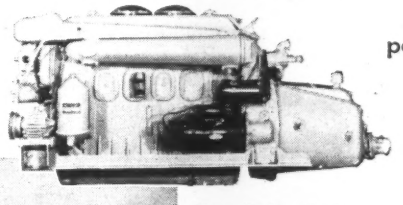
have great power transmission capacity for their weight, just as

GRAY MARINE DIESELS

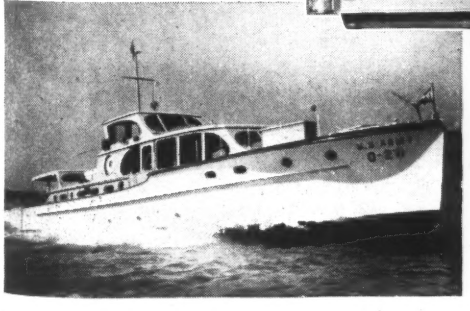
have great power output per pound

● Small boats—lighters, landing boats, picket boats, mine sweepers—are playing a big part in winning the war, and Diamond Roller Chains are used regularly in the engines of a large majority of these craft.

Compactness is the essence of small boat engine design, therefore the engine which can be relied on to deliver the most power for the least weight and bulk is the optimum design.



Fast 60-foot Army ship built by Chris-Craft, powered by a pair of Gray Marine Diesels.



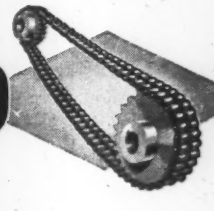
Six cylinder, 165 h.p., 2000 r.p.m., equipped with Diamond Roller Chain lubricating oil pump drive.

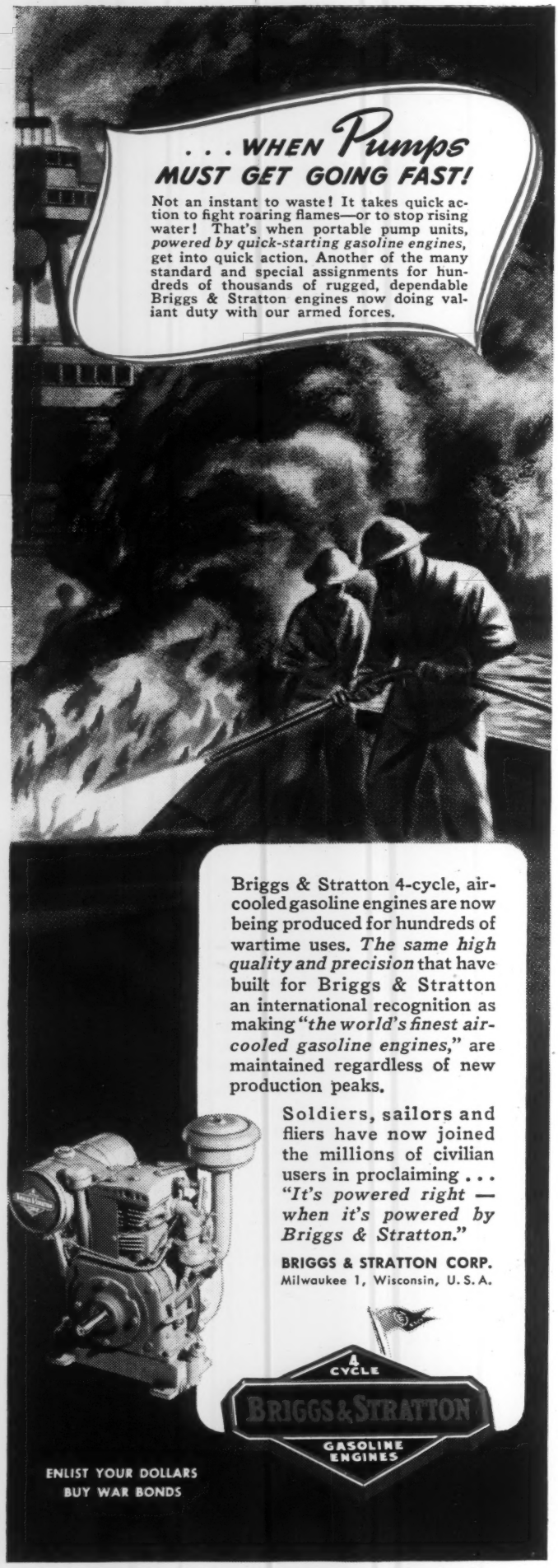
Compact, reliable, high output Gray Marine Diesels—good small boat engines—are used extensively by our armed forces to power all types of light craft.

Compact, reliable, high power transmission capacity Diamond Drives—good equipment for all engines—have been proved by 32 engine builders on more than a hundred different models.

Diamond Drives simplify engine design—they are positive, run quietly, and are long lived.

If you have engine conversions, engine redesigns, or entirely new developments in prospect, let our engineers—with years of engine application experience—cooperate with you in the design of timing and accesscry drives. DIAMOND CHAIN & MFG. CO., 435 Kentucky Ave., Indianapolis 7, Indiana. Offices and Distributors in All Principal Cities.

DIAMOND  **ROLLER CHAINS**


. . . WHEN Pumps MUST GET GOING FAST!
Not an instant to waste! It takes quick action to fight roaring flames—or to stop rising water! That's when portable pump units, *powered by quick-starting gasoline engines,* get into quick action. Another of the many standard and special assignments for hundreds of thousands of rugged, dependable Briggs & Stratton engines now doing valiant duty with our armed forces.
Briggs & Stratton 4-cycle, air-cooled gasoline engines are now being produced for hundreds of wartime uses. *The same high quality and precision* that have built for Briggs & Stratton an international recognition as making "*the world's finest air-cooled gasoline engines,*" are maintained regardless of new production peaks.
Soldiers, sailors and fliers have now joined the millions of civilian users in proclaiming . . . "*It's powered right — when it's powered by Briggs & Stratton.*"
BRIGGS & STRATTON CORP.
Milwaukee 1, Wisconsin, U. S. A.
4 CYCLE
BRIGGS & STRATTON
GASOLINE ENGINES
ENLIST YOUR DOLLARS
BUY WAR BONDS

Co. From 1915-1918 he served as eastern manager of Lakewood Engineering Co. and then became connected with Superheater Co. Mr. Gates, a registered professional engineer in New York State, has been active in the affairs of the Society since becoming a member in 1918. He served as manager from 1928 to 1931, and later as vice president, as well as being on various standing committees including meetings and program and professional divisions. For the 1941 annual meeting, Mr. Gates —as chairman of the committee on conservation and reclamation of materials in industry—organized a "panel of experts" to conduct a session on conservation and reclamation. Among his other accomplishments are numerous addresses before engineering groups and many contributions to engineering literature.

♦

JOHN W. HADDOCK has resigned as vice president in charge of engineering and sales of The Sullivan Machinery Co. to become president of the Farrel-Birmingham Co., Ansonia, Conn.

♦

ROE S. CLARK, vice president and treasurer of the Package Machinery Co., has been re-elected president of the National Metal Trades association at its forty-fifth annual convention.

♦

LEIGH WILLARD who once was a draftsman was recently elected a director of Allis-Chalmers Mfg. Co., Milwaukee, to fill the vacancy left on the board by the death of Max W. Babb. Mr. Willard is also president and director of the Interlake Iron Corp.

♦

DR. JOSEPH SLEPIAN was recently presented the Benjamin Garver Lamme medal, awarded annually by the American Institute of Electrical Engineers, for meritorious achievements in development of electrical apparatus or machinery. Dr. Slepian, who had been an associate of Mr. Lamme at Westinghouse, is an associate director of the Westinghouse Research Laboratories.

♦

WILLIAM P. WOODSIDE has resigned as vice president in charge of research, Climax Molybdenum Co. While he intends to spend the major portion of his time on his farm, he is still retaining his interests in Park Chemical Co., and American Twist Drill Co. of which he is chairman.

♦

DAVID MACGREGOR who has been connected with The Edward Valve & Mfg. Co., Inc., in various engineering capacities since 1925, is now chief engineer of the organization.

♦

FRED H. WILHELM, in charge of the design of small machines, The Thew Shovel Co., has been appointed chief draftsman and assistant to the chief engineer.

♦

J. L. TRECKER has been advanced to executive vice president of Kearney & Trecker Corp. J. B. Armitage has been made vice president in charge of engineering.

♦

WILLIAM A. CRESSWELL JR. has been transferred from analytical engineer to junior project engineer in the stress

FROM THE ARMY'S NEW RAINCOAT . . . A HIGH SPEED RESTING MACHINE!

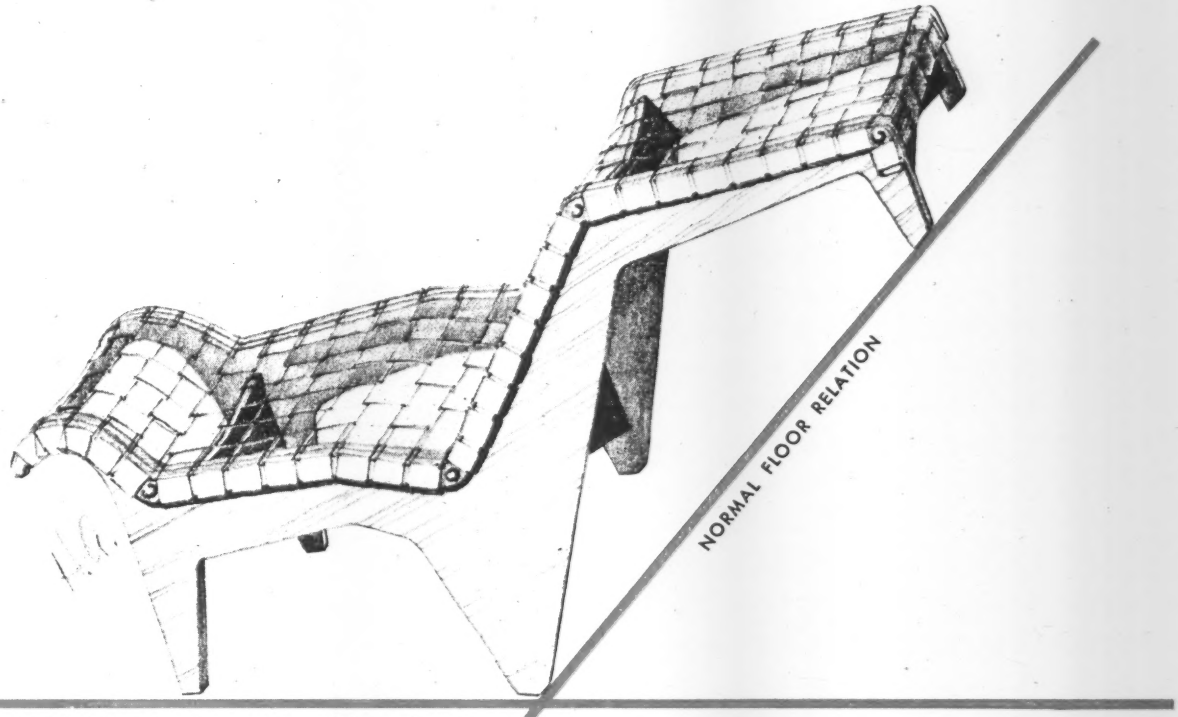
Harris Armstrong, A.I.A., has studied at Washington University and Ohio State, worked under the late Raymond Hood. From his St. Louis office during the past ten years have come many notable residences and doctors' buildings. For many of these he has also designed furniture.

ST. LOUIS Architect Harris Armstrong may have had his tongue in his cheek when he named the chair he has sketched below — but he was on sound ground when he designed it to take advantage of a physiological fact long recognized by athletes and ballet dancers: *i.e.*, the human machine relaxes more easily and completely with feet perched higher than the head.

One of the most interesting features of Mr. Armstrong's design is its effective use of Saflex, a material which epitomizes the great versatility of modern plastics and the great strides they have made in answer to wartime needs.

For example, in the Army raincoat Mr. Armstrong is examining in the photograph, Saflex now replaces rubber with marked success, yet the first Saflex compounds were developed to serve as thermoplastic binders for high test safety glass. To fit Saflex for its new job, it was transformed almost overnight from a thermoplastic into a thermosetting material that qualifies as the most rubber-like of all plastics.

In its new formulations, Saflex can be vulcanized and otherwise handled almost exactly like rubber. It can be given a variety of interesting textures and any color, even clear transparent. Particularly it is resilient without actually being elastic—a quality which led Mr. Armstrong to specify webbing woven from board strips of Saflex for his ultra-comfortable chair.



FLOOR RELATION FOR HIGH SPEED RESTING

Chair's frame would be strong, lightweight, weather and water-resistant, plastics-bonded plywood. Brightly colored, interestingly textured Saflex webbing would also be waterproof so that the chair could serve equally well in or outdoors and would be simple and easy to clean. In addition to the sheet-form specified here, Saflex is also supplied as molding compounds and in formulations for coating fabric as in the Army raincoat.

The Broad and Versatile Family of Monsanto Plastics

(Trade names designate Monsanto's exclusive formulations of these basic plastic materials)

LUSTRON (polystyrene) • SAFLEX (vinyl acetal) • NITRON (cellulose nitrate) • FIBESTOS (cellulose acetate) • OPALON (cast phenolic resin) RESINOX (phenolic compounds)

Sheets • Rods • Tubes • Molding Compounds • Castings • Vuepak Rigid Transparent Packaging Materials

MONSANTO PLASTICS

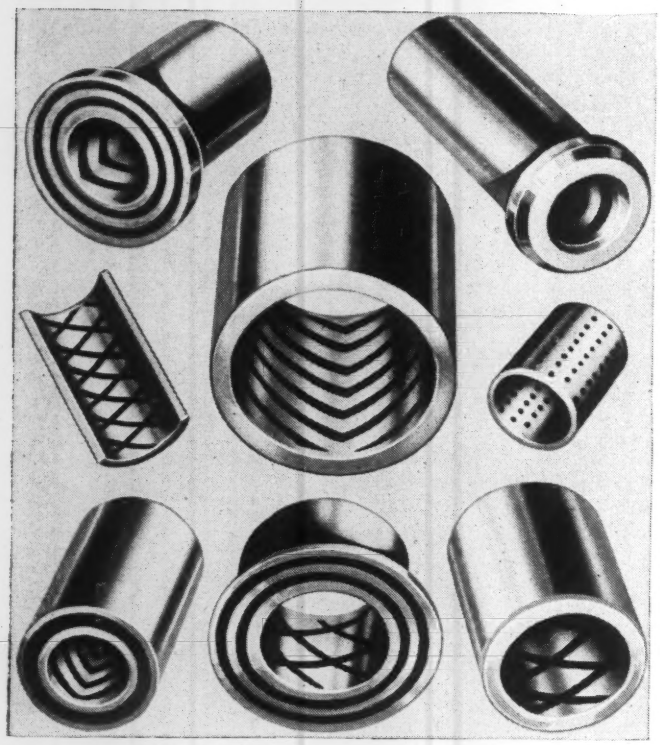
SERVING INDUSTRY...WHICH SERVES MANKIND

FACTS FOR POSTWAR PLANNERS

Saflex and the Resinox or melamine bonding resins which might be used in the plywood frame of Mr. Armstrong's chair are just part of the large Family of Monsanto Plastics, probably the broadest and most versatile group of modern plastics offered by any one manufacturer.

For facts on the entire family—and an overall picture of what plastics are, how they are fabricated and what they promise in the future — see the 24-page guide to Monsanto Plastics recently prepared for product designers. Simply write: MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield, Massachusetts.

FOR BETTER MACHINES AND APPLIANCES



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FOR BETTER MACHINES AND APPLIANCES

and vibration department of Ranger Aircraft Engines, Division of Fairchild Airplane & Engine Corp., Farmingdale, L. I., N. Y.

♦

ALVIN J. KORNBLUM is now project engineer of Huges Aircraft Co., Armament division, Hollywood, Calif. Formerly he had been assistant project engineer of Vega Aircraft Corp., Seattle, Wash.

♦

GUNNAR JENSEN, chief engineer of Walker Mfg. Co. of Wisconsin, Walker Michigan division, Jackson, Mich., has recently been transferred to the Racine, Wis., office in a similar capacity.

♦

SERGE L. CROWELL has resigned as designing engineer of Babcock & Wilcox Co., New York, to accept a position as helicopter designing engineer with Sikorsky Aircraft, Division of United Aircraft Corp., Bridgeport, Conn.

♦

ROBERT P. VAIL, who formerly was head of the mechanical engineering department of the Pantex Ordnance Plant at St. Francis, Tex., has joined the Cabot Co., Pampa, Tex., as assistant chief engineer.

♦

LESLIE C. SMALL JR., layout draftsman, has been promoted to designer of aircraft engines, Pratt & Whitney Aircraft Division of United Aircraft Corp., East Hartford, Conn.

♦

ARTHUR M. FITZPATRICK, formerly designing engineer in charge of styling, Stinson Aircraft division, Consolidated Vultee Aircraft Corp., Wayne, Mich., has joined John Tjaarda & Associates, Detroit, to engage in research and experimental designing and engineering on aeronautical, automotive and industrial equipment.

♦

WILBUR F. SHURTS has become chief engineer of the Hydraulic division, Twin Disc Clutch Co., Rockford, Ill. He had previously been employed in the capacity of development engineer.

♦

EDWIN WINKLER, a junior design engineer, Douglas Aircraft Inc., El Segundo, Calif., has been made aeronautical design engineer of the company, and is now located in Tulsa, Okla.

♦

LEONARD TROY, vice president in charge of engineering, Strickland Aircraft Co., Topeka, Kans., is now aeronautical engineer at the Spartan Aircraft Co., Tulsa, Okla.

♦

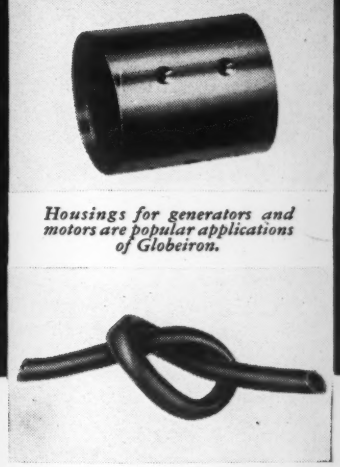
CHILDRESS BUCKNER GWYN JR., for the past eight years chief engineer of Fansteel Metallurgical Corp., Chicago, has been appointed chief engineer and general manager of the Chicago division, Allied Control Co., Inc.

♦

WILLIAM WADDELL has been appointed special engineer at the Studebaker Corp., South Bend, Ind. He formerly had been chief draftsman, Lycoming division, The Aviation Corp., Williamsport, Pa.

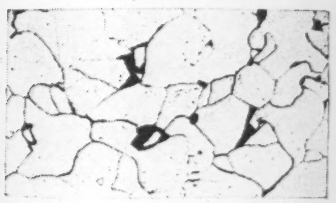
YOU HAVE LONG WANTED TUBING LIKE...

Globeiron



Housings for generators and motors are popular applications of Globeiron.

The ductility and toughness of Globeiron make it ideal for severe forming operations.



Under the microscope Globeiron shows a uniform structure of almost pure ferrite with only occasional patches of pearlite.

★ **HIGH MAGNETIC PERMEABILITY**

★ **UNIFORM DUCTILITY AND SOFTNESS**

★ **CORROSION RESISTANT**

This high-purity ingot iron seamless tubing, developed by Globe engineers, meets a definite need for high magnetic permeability, uniform ductility, softness and toughness.

Since Globeiron is seamless, its magnetic permeability is uniform throughout its cross section — a highly important advantage where magnetic permeability is a desired factor.

Worked hot or cold, Globeiron permits fabrication into almost any form and requires less thickness than steel. Superior in corrosion resistance, Globeiron gives longer service in applications where corrosive attack is accelerated by segregations or by the non-homogeneity of steel.

Send for Bulletin 109 — giving condensed technical information on Globeiron tubing.

In selecting the tubing with the exact characteristics you require, Globe engineers offer their services, with excellent laboratory facilities and production capacity to assure economy and quality control.

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Type K Cannon Connectors are light in weight yet rugged and durable. Made in three basic types... Wall Mounting Units, Straight and 90° Cord Connectors.
CANNON CONNECTORS
...find effective use with
Vibration Testing Equipment

In this delicate scientific equipment developed and used by Consolidated Engineering Corporation for measuring acceleration, velocities and displacements, uninterrupted operation is of paramount importance.

The use of this equipment requires frequent coupling and uncoupling of fittings and Consolidated Engineers have found that Cannon Connectors save time and are uniformly dependable under all conditions.

Because of the wide variety of shapes, sizes and contact arrangements which are STANDARD with Cannon, and because of their dependability, Cannon Connectors are used in ever-increasing numbers in war and peacetime industry.

The Cannon Catalog Supplement gives data on Type K and seven other types of generally used connectors. Send us a request on your business letterhead and we will mail you a copy. Address Department A-107, Cannon Electric Development Company, Los Angeles 31, Calif.

CANNON ELECTRIC

Cannon Electric Development Co., Los Angeles 31, Calif.

Canadian Factory and Engineering Office:
Cannon Electric Co., Ltd., Toronto, Canada

Representatives in principal cities—consult your local telephone book

NOTEWORTHY PATENTS

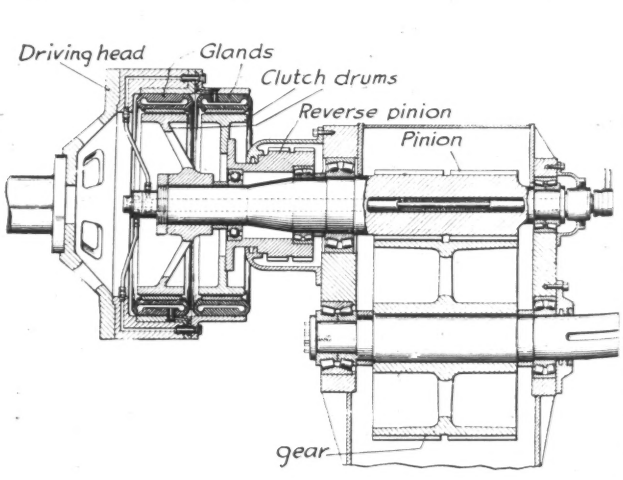
Air Pressure Controls Reversing Drive

CLUTCH control in reversing drive mechanisms presents interesting problems, especially where the power to be transmitted is relatively high. A solution employing fluid couplings was recently described in this department (MACHINE DESIGN, May, 1943, page 158), while the present discussion is concerned with a design utilizing pneumatic control. The mechanism is covered by patent 2,304,031, recently assigned to The Falk Corp.

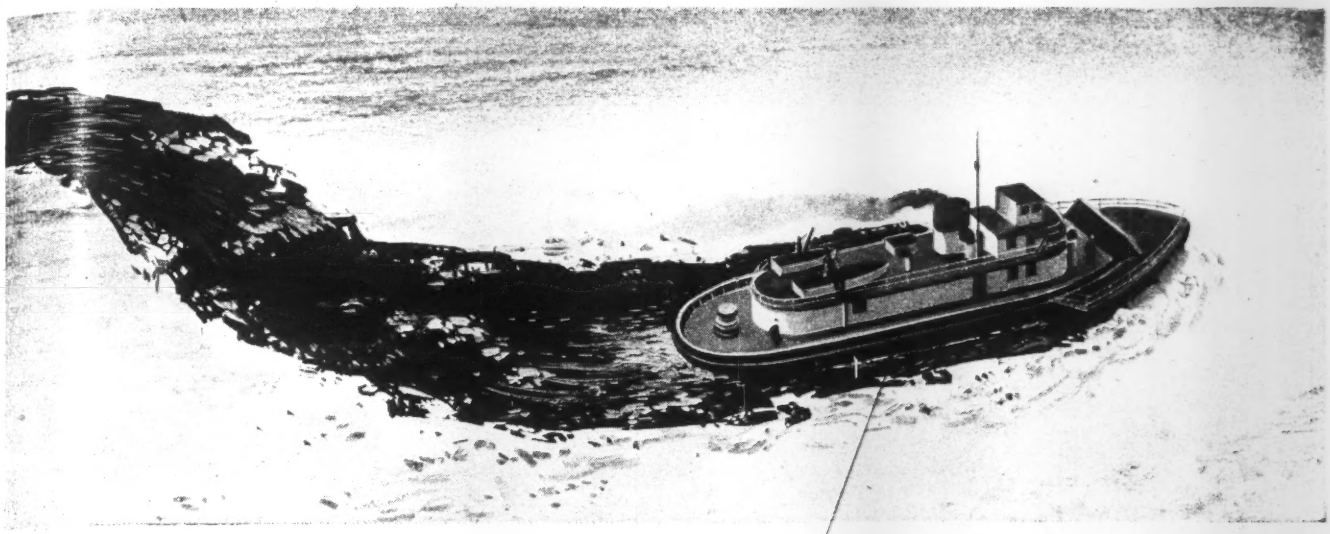
In the illustration the reversing drive mechanism is shown applied to a single-reduction gearbox comprising a pinion and driven gear. The projecting end of the pinion shaft carries a driven clutch element in the form of a drum, which is concentric with the driving element. Driving element carries an annular tubular gland of flexible material such as rubber or rubber composition reinforced with cords or fabric. The gland constitutes a fluid-pressure container carried by the driving head which, when expanded, grips the drum or driven element with sufficient force to transmit the necessary torque.

A second, similar, gland also is carried by the driving head and encircles a clutch drum which is attached to the flange end of a hollow pinion supported on bearings mounted on the main pinion shaft. The hollow pinion meshes with a similar pinion (not shown) attached to the end of a countershaft, the other end of which carries a second pinion meshing with the main driven gear.

When both glands are deflated the clutches are open and the driving head rotates idly. When the left-hand gland is inflated and the right-hand gland deflated the main pinion rotates in unison with the driving head and drives the gear in the forward direction. When the left and right-hand glands are, respectively, deflated and inflated, the reversing pinion rotates in unison with the driving head and, through it and the countershaft gears, the



Air pressure expands flexible gland against clutch drum, left-hand unit operating the direct drive, right-hand unit being used for the reverse drive



This W·A·B remote control installation opens new channels of *product improvement* too . . .

How well W·A·B Remote Control equipment might serve on *your* product or production machinery is best demonstrated by the variety of complex jobs it is already doing.

Take this Ice Breaker, for instance. All the operations involved in maneuvering the engines . . . speed control, clutching or declutching, braking, and reversing . . . are governed by five or six inches of travel of two small handles, a hand's-breadth apart on the control stand. An easy, back-and-forth movement of another handle actuates the rudders. The dependability and responsiveness of the controls were picturesquely summed up by the operator, when he said, "I could write my name in the ice with this ship."

If you manufacture any mechanical device where a cycle or series of operations are controlled from some central point . . . or if in your plant there is need for some similar control . . . the chances are that W·A·B Remote Control Systems will do the job better, easier, and at less cost. In many instances standard, "off the shelf" W·A·B devices, immediately available, are all that are required. If you will outline your control problem, one of our representatives will be glad to make recommendations. Write, wire or phone.

Westinghouse Air Brake Company

INDUSTRIAL DIVISION

General Offices: Wilmerding, Pa.

74 Years of Pneumatic Control Experience

W·A·B

PNEUMATIC
PNEUMATIC-ELECTRIC
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remote control systems

BD-72

● Military authorities doubt that the war will be won by any secret super weapon. They count on fighting efficiency developed out of many small things — advantages gained from foresight and painstaking attention to detail.

For example, take the BD-72 portable military switchboard developed at *Connecticut,* in cooperation with Signal Corps engineers. It has many features we can't tell you about, but we can say that the BD-72 was designed to save space, to get into operation faster, to stand a lot of rough usage under fighting conditions. Small things? Not if its small size permitted getting one more machine gun aboard the truck. Not if it helps "get the message thru" even *seconds* sooner. Small things sometimes loom large when the job is to get the jump on the enemy.

All over America, the doom of the Axis is being made more and more certain by giving the fighting men of the United Nations better fighting tools. The birth of better ways of doing things *after* the war, is an all-important by-product of this effort. *Connecticut Telephone & Electric* is an excellent source of ideas for developing your postwar product or manufacturing methods, if they involve communications, or the engineering and manufacture of precision electrical devices.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

GREAT AMERICAN INDUSTRIES

MERIDEN, CONN.

ARMY E NAVY

For the second time within a year, the honor of the Army-Navy Production Award has been conferred upon the men and women of this Division.

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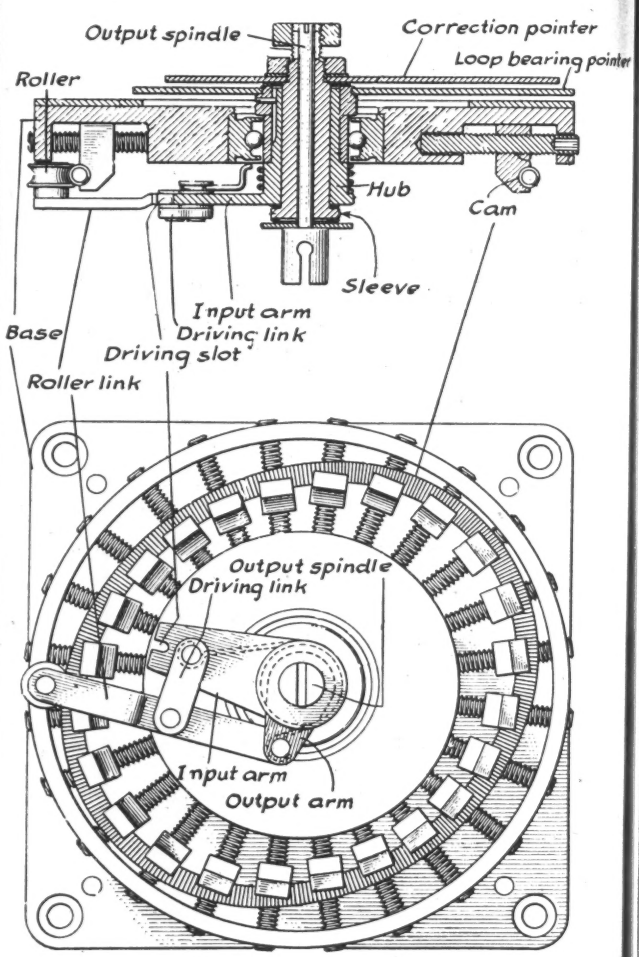
main gear is driven in the reverse direction.

Supply and release of fluid pressure to and from the glands are effected through drilled passages in the driving head. Pipe connections lead to the hollow main pinion shaft which carries an internal sleeve, providing two independent passages. Air pressure from the control station is supplied through a joint at the right-hand end of the main pinion shaft.

Adjustable Cam Compensates for Errors

AN ADJUSTABLE cam mechanism for increasing or decreasing an input movement by any predetermined amount and transmitting the modified movement to the output end is the subject of patent 2,322,031, recently assigned to Fairchild Aviation Corp. The device has been developed primarily for compensating radio compasses on aircraft, where the signals reaching the rotatable loop antenna from certain directions are distorted through interference from parts of the plane such as wings and engines. Thus when the wave is picked up by the radio compass the true bearing is not indicated on the compass card. The mechanism covered by the patent receives the motion of the loop antenna as an input and transmits the corrected motion as an output to the compass card through an appropriate telemetering device.

Essential parts of the cam mechanism are shown in the



Flexible cam track formed by tightly coiled spring on adjustable blocks actuates linkage, effecting relative motion between input and output arms

PROBLEMS THAT COME TO GILMER

IF you are designing new drives for V-belts—flat belts—round belts, you will find the completeness of the Gilmer line and Gilmer engineering counsel valuable and time-saving.

Gilmer specializes in belts! As the oldest firm of rubber-fabric belt specialists, with over a third of a century of experience in building belts for machinery all over the world . . . Gilmer has developed a complete line of highly specialized belts for use where standard belts are unsuited. Engineering and manufacturing facilities are maintained for high-speed belts, light duty fabric belts, special endless belts, planer belts, and round belts. Oil-resistant and static-dissipating construction . . . both are available.

The Gilmer Engineering Staff welcomes the opportunity to make recommendations on the development of drives for new machinery or the redesigning of drives to produce greater efficiency. You reduce your customers' maintenance troubles to a minimum when you equip machinery with Gilmer Belts. By suggesting Gilmers, you are prescribing the *best* in Belts.

FAMOUS GILMER BELTS

GILMER V-BELTS: Made in standard and special sizes on the largest assortment of V-belt moulds in the world. Space-saving, silent, shock-absorbing belts, built to lock in the groove with a rugged, non-slip grip.

GILMER HEVALOID ENDLESS BELTS: Exclusive with Gilmer in the U. S., by a patented process. Light weight and vibrationless for high speed precision work. Resists oil, heat, stretch and slippage.

GILMER KABLE KORD BELTS: Rubber fabric and tough continuous cord construction gives you a contactor and power belt in one. Exceptional grip and strength combines in these flat belts with low-stretch, small slippage and extra tensile strength.

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The Oldest Firm of Rubber Fabric Belt Specialists

V-Belts (F.H.P. & Multiple); Flat Belts; Round Endless Belts; High Speed Belts; Fabric Belts; Planer Belts; Special Endless Belts

Gilmer BELTS

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IT will pay you to consider the advantages of electric heat; cleanness, ease of installation, economy, and long life with minimum maintenance.

WITH G-E FIN CALRODS, the advantages of electric heat are EASY to obtain. They will provide uniform air flow in your process machinery, air-blast ducts, or blower-type heaters.

CLEANNESS—There are no products of combustion to contaminate the air.

EASE OF INSTALLATION—These Fin Calrods can be bent into practically any shape desired, and without injury. They can be readily made to fit into your machines. Special bushings are provided to facilitate mounting. Simple electric wiring completes the installation.

ECONOMY, AND LONG LIFE WITH MINIMUM MAINTENANCE—Because their initial cost per kilowatt is very low,* and because only occasional inspection is necessary.
General Electric, Schenectady, N. Y.

*For example—one 2000-watt, 230-volt, 24-inch heater (with a maximum allowable sheath temperature of 1000 F) costs just $7.40. Cat. No. 7A110. Priority AA2X or better.

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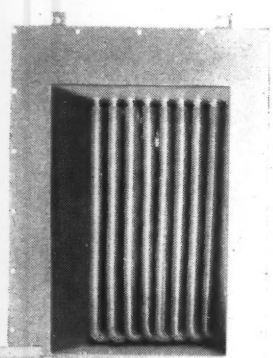
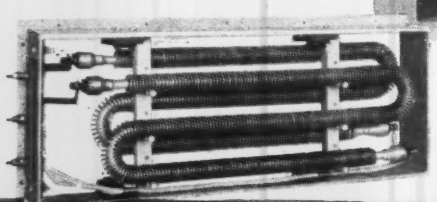
- **Air-conditioning systems**
- **Recirculating ovens**
- **Drying equipment**
- **Resistor-load banks**
- **Test equipment—warm air**
- **Unit air heaters**
- **Dehydrating equipment**





Typical installation of G-E Fin Calrod heaters for an air duct.

Here two G-E Fin Calrod heaters are mounted in a frame such as is used in a recirculating oven duct.

GENERAL ELECTRIC

accompanying figure. A ball bearing pressed into the central hole of the fixed base carries a sleeve which is keyed to the extended hub of the input arm. A slot at the end of the tapered input arm engages a pin which rotates in proportion to the movement of the loop antenna. Secured to the upper end of the hub is a pointer which moves over a scale and indicates the loop bearing.

Within the hub and concentric with it is a hollow sleeve which is free to rotate relative to the hub. It is actuated by the input arm through a linkage consisting of a driving link, roller link and output arm integral with the sleeve. Provided there is no relative motion in this linkage, movement of the output arm coincides with that of the input. However, when it becomes necessary to correct the output this can be done by adjusting the cam track over which the roller rides.

Cam is formed by a tightly coiled circular spring which is retained in grooves formed in shoes adjustably disposed within an annular channel in the base. Each shoe has a threaded hole which engages an adjusting screw by which the radial position of the block may be adjusted. Spring tension holds the screws and blocks in their adjusted positions, and the cam contour may be changed at will within the limits of the annular channel.

As the roller rides over the contour of the cam due to rotation of the input arm, the linkage connecting the input and output arms experiences relative motion, causing movement of sleeve with respect to the hub. The sleeve is secured to the output spindle at the top by means of a split screw with a tapered thread, permitting adjustment. Also attached to the sleeve is a pointer which moves over a scale on the loop bearing pointer and indicates the correction.

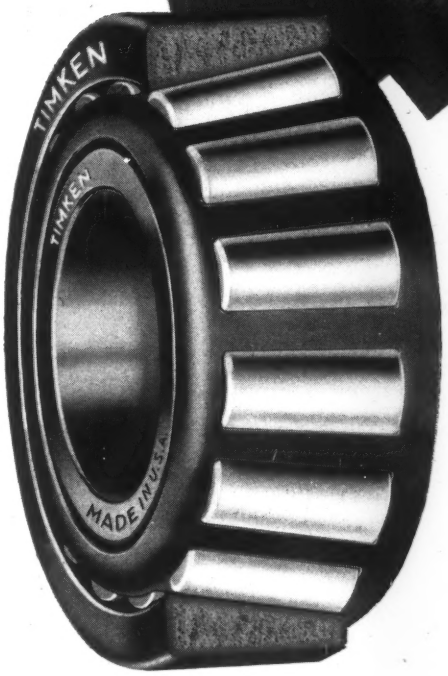
Calibration is accomplished by adjusting the supporting blocks until the known corrections are indicated on the correction scale, this being done for each 15 degrees of rotation. When properly calibrated the output spindle rotates an amount corresponding to the true bearing of the plane with respect to the radio signal wave.

Cooling Increases Bolt Strength

TEMPERATURES attained in modern steam turbines are sufficiently high to affect the strength of materials used in the bolts which hold the parts of the cylinder in pressure-tight relationship. Provision of cooling by means of a circulating fluid is offered as a means of improving the holding capacity of such bolts, and is covered by patent 2,320,398, recently assigned to Westinghouse Electric & Manufacturing Co.

Typical of several alternative designs is the arrangement shown in the accompanying illustration. Turbine cylinder flanges are held together by bolts provided with nuts and washers at each end. Clearance spaces between the bolt shanks and the walls of the bolt holes are closed at the ends by the nut assemblies, and are utilized as a part of the means for circulating cooling medium over the bolt shanks. Cooling fluid is supplied from a header and branch passages to drilled openings in one of the flanges. In the design shown, the bolt hole in the lower flange is counterbored to receive the lantern portion of a tubular baffle, the annular ribs fitting tightly in the counterbore and defining a distributing chamber through which cooling

When peace comes the lessons of destruction will be translated into machines for production with startling swiftness. What are your plans for the future? Even though you are busy with war orders today, are you planning to take full advantage of the latest scientific developments? Refinements in machine design invariably mean more Timken Bearings. True, a few Timken Bearings are better than none, but a fully Timken-equipped machine is both a better selling and better performing machine. Our engineering staff is available.

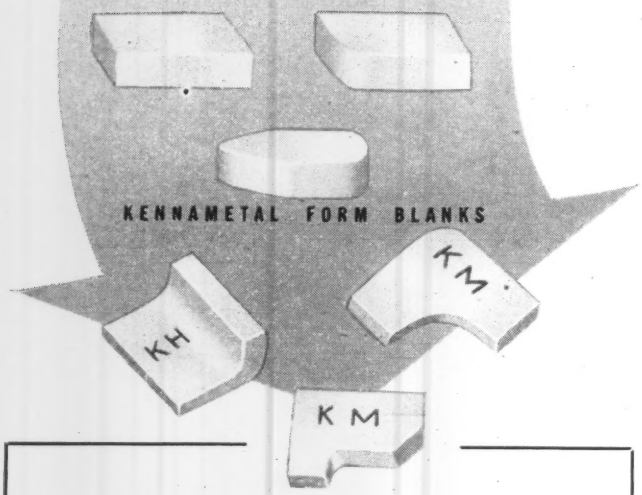


Tapered Roller
TIMKEN BEARING
EQUIPPED

A symbol of quality for any piece of equipment with which it is associated.

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

KENNAMETAL *Blanks*



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★ KENNAMETAL steel-cutting carbide tools can be made in your shop by torch brazing KENNAMETAL standard or formed blanks to used steel shanks. This technique eliminates the maintenance of large tool stocks and affords a fast, economical, and convenient method of tool supply.

KENNAMETAL blanks are available in four grades of hardness, KM, KH, K3H, and K4H. The standards are supplied in three styles; formed blanks are shaped to specifications.

The "stocking up" of KENNAMETAL standard and formed blanks will insure your shop of an adequate tool supply without excessive capital investment.

Write today for the KENNAMETAL Catalog 43B—it contains information on blanks and the proper method of brazing them to shanks.

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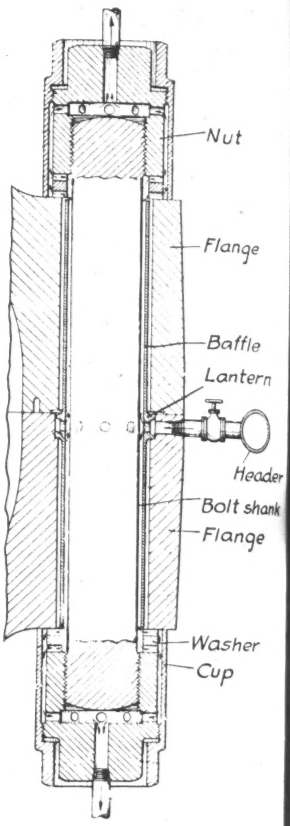

Circulation of air or low-temperature steam over shank and nuts of turbine bolting is used to maintain and control bolt tension

fluid flows to the clearance space between the bolt and the baffle. Fluid flows in opposite directions toward the nut assemblies at the bolt ends, the baffle providing a flow path of uniform area in which velocity of flow is adequate for heat transfer. Dead space between the baffle and wall of bolt hole serves to insulate flanges from bolt.

Each washer is bored to a diameter somewhat larger than the bolt shank so as to provide an annular space in communication with the flow passage between the shank and the baffle. Radial passages in the washer conduct the cooling fluid to the outside of the nut, which is enclosed by an outer skirt or cup. After flowing over the outside of the nut the fluid enters a series of radial passages in the nut itself into the space between the bolt shank and nut, whence it is discharged. Air or low-temperature steam may be used as cooling medium.

It will be noted that the radial passages in the washers are arranged close to the flange and nut face, thus reducing the contact area for heat conduction to the nut. Cooling surface can be controlled by making slots deeper washers of suitable thickness being provided. Divided flow of cooling medium along the bolt shank insures comparatively uniform bolt temperatures compared with previous proposals to cool bolts by the use of hollow bolts with end-to-end flow. It is, of course, entirely feasible to reverse the direction of flow if desired.

Inasmuch as the bolt temperature is considerably less than that of the flanges, it is evident that cooling provides a means of tension control due to differential expansion. Each branch passage is provided with a valve, affording a means of controlling the individual bolt temperatures. In case a leak develops at the flange, increased flow of cooling medium to the bolts in the region of the leak can be used to effect additional pressure on the flanges

Typical cranking motor manufactured by the Leece-Neville Co. for starting excavating machinery, military and naval vehicles, trucks, tractors, rail cars, and busses —wherever diesel and gasoline motive power is used. For many years, this company has fabricated parts for these mechanisms from OSTUCO seamless steel tubing. Photo courtesy The Leece-Neville Co., Cleveland, Ohio.

Photo courtesy The Osgood Co., Marion, Ohio

YOU'LL FIND OSTUCO SEAMLESS STEEL TUBING WHEREVER GASOLINE AND DIESEL ENGINES DIG IN FOR VICTORY

Victory developments demand new roads, war-worker and war-material transportation on the home front. Far-off war fronts require new landing fields, roads and conveyance for men and equipment. In the myriad of Victory vehicles and machines performing these arduous tasks today you'll find OSTUCO seamless steel tubing on the job.

For example, OSTUCO supplies tubing for the pole pieces and field rings in cranking motors used in starting gasoline and diesel engines. This involves milling low carbon seamless steel tubing to meet strict dimensional specifications—maintaining desired magnetic properties—satisfying machinability requirements—and keeping pace with continuous refinements and design improvements.

What does this mean to you? It means that when you are ready to go ahead with the post-Victory production, OSTUCO will be ready with a reservoir of new experience on which you can draw to help meet demands for precision, volume output and low cost.

BUY MORE WAR BONDS

GET IN THE SCRAP

WRITE TO THE MEN IN SERVICE

BE ON THE JOB EVERY DAY

THE OHIO SEAMLESS TUBE COMPANY

MANUFACTURERS OF SEAMLESS AND ELECTRIC-WELD STEEL TUBING

SHELBY OSTUCO OHIO

AEROFELT Transmission Cover Weather Pad.

Buy War BONDS . . . Help Win The War — Use BONDED FELT . . . Save Critical Materials.

FELT IS NOW BONDED

To Form Intricate Jeep Parts

Unique in its construction is the new Transmission Cover Weather Pad illustrated. This intricate part used on jeeps and other military vehicles, is made of two pieces of FELT (S.A.E. F-13) cut to exact specifications and bonded together, then treated with AEROFELT (Type F) to render the part completely waterproof.

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PRODUCERS OF FINEST QUALITY PARTS FOR OIL RETAINERS, WICKS, GREASE RETAINERS, DUST EXCLUDERS, GASKETS, PACKING FELTS, VIBRATION ISOLATING FELTS, INSULATING FELTS AND "K" FELT

ASSETS to a BOOKCASE

Mechanics of Materials

By S. G. George, E. W. Rettger and E. V. Howell, Cornell University; second edition, published by McGraw-Hill Book Co. Inc., New York; 491 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$3.75 postpaid.*

One cannot dispense with this book as just another of the host of treatises dealing with strength of materials. A sincere and commendable effort has been made by its authors to present their subject in as simple and comprehensive a manner as the topic permits.

Methods of analyzing problems in stress and strain are always of pertinent interest to machine designers. The straightforward and practical manner in which such problems are set up and solved in this volume should make it not only a valuable instructor but a handy reference manual as well. Its adequate number of illustrations are well chosen and serve effectively to qualify the printed word.

Thorough treatment is afforded such phases of the subject as stress and strain, tension and compression, riveted joints, torsion, simple beams, stress intensities on different planes, columns, nonprismatic and special beams, etc. Standard procedures in testing for materials strength characteristics are included and the reader should find Chapter IX with its slope-deflection method and theorem of three moments of considerable value in work requiring structural analyses.

Die Engineering Layouts and Formulas

By C. W. Hinman, former chief of jig and fixture designing, Western Electric Co.; published by McGraw-Hill Book Co., New York; 497 pages, 6 by 9 inches, clothbound; available through MACHINE DESIGN, *$5.00 postpaid.*

This book endeavors to combine the basic mechanical principles of assembled die design with their operating details, to give the necessary mathematical formulas for laying out the assembled die, and to emphasize a clearly rendered drafting technique. Dies shown for war production, and the short cuts explained for drafting them, reveal the basic principles of many key designs that will have an endless number of applications after the war.

While primarily aimed at the tool engineer, this practical and complete treatise also offers material which should prove of value to designers in general. Perhaps most interesting of its contents, from the machine designer's standpoint, are Chapters VIII and XIV. The first of these, dealing with mechanisms for parts and stock feeding, may well suggest ideas for feed designs to be used in various types of machinery. In the later chapter, parts fabricated through the combination of

Advantages of RED RING GEAR TOOTH SHAVING

1. Corrects gear cutting errors of index, helical angle, tooth profile, eccentricity, and tooth roughness.
2. Applicable to spur gears, helical gears, cluster and shoulder gears, and internal gears.
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4. Requires only a small fraction of the machining time required by grinding, for the same quality of product.
5. Gears shaved and hardened are free from microscopic cracks in the tooth surfaces such as occur in ground gears.
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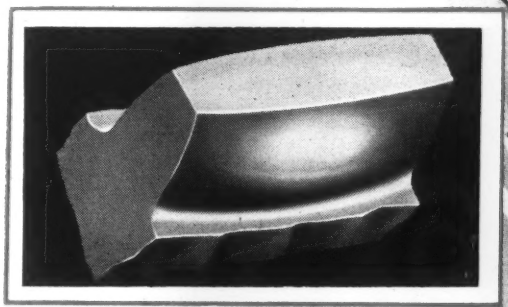

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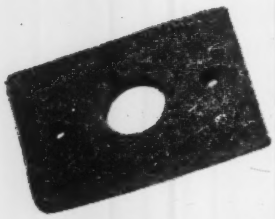

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□ □ □

Handbook of Plastics

By Herbert R. Simonds, Carleton Ellis and M. H. Bigelow, C.W.S., Capt., U. S. Army; published by D. Van Nostrand Co. Inc., New York; 1082 *pages,* 6½ *by* 9¼ *inches, clothbound; available through* MACHINE DESIGN, $10.00 *postpaid.*

Many of the plastics industry's leading technicians have contributed to the contents of this book, the net result being a volume which provides complete data for all who are concerned with the development, manufacture and myriad applications of plastics.

Following a plastics industry survey which includes a listing of the country's leading molding companies, the book proceeds with such topics as plastics materials, manufacturing technique and equipment, chemistry of plastics, applications of plastics, commercial considerations, etc.

Of especial interest to machine designers will be its chapters dealing with the design of molded parts and the various properties of plastics. Chapter II offers complete tabulated data covering the specific, thermal, mechanical, electrical and molding characteristics of plastics materials. In another section the desirability of uniform wall thickness in molded parts is stressed, recommended practice for designs requiring metal inserts is given, and information is furnished on tolerances, fastenings and hinges, molded and machine-tapped threads, fillets, knurling, surface finishes, etc.

□ □ □

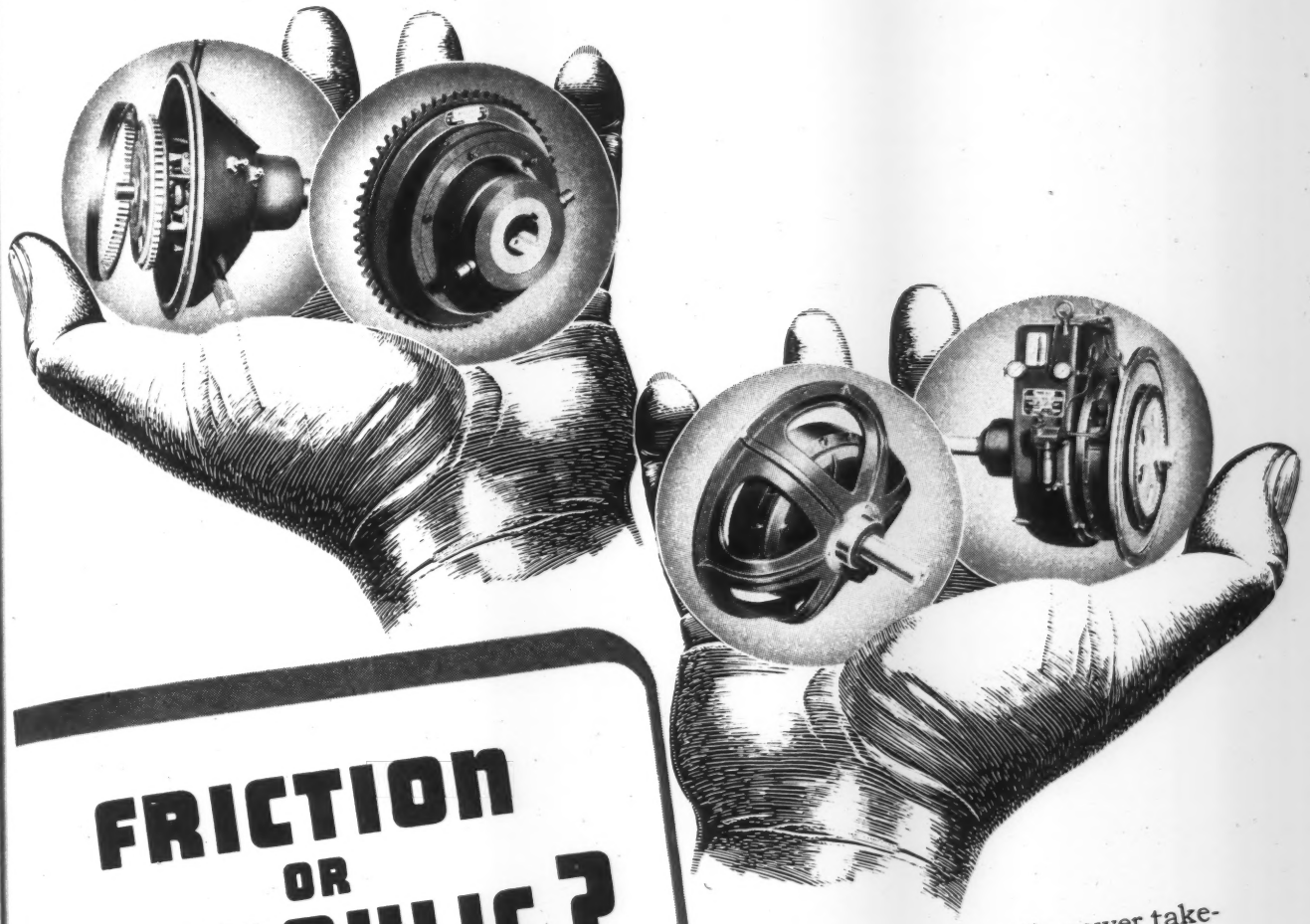
Industrial Production Illustration

By Randolph Philip Hoelscher, Clifford Harry Springer and Richard F. Pohle; published by McGraw-Hill Book Co. Inc., New York; 213 *pages,* 8½ *by* 11 *inches, paper covers; available through* MACHINE DESIGN, $3.50 *postpaid.*

With pictorial art being used so extensively to help facilitate production in our many war industries, this manual is particularly timely. Production breakdown perspectives and the exploded-view type of assembly presentations shown, are utilized in many plants with gratifying success to aid in the instruction of assembly-line workers.

Included in the contents are chapters on lettering, orthographic projection and sketching, axonometric projection and sketching, oblique projection and sketching, perspective, engineering delineation, uses of pictorial drawing and shading.

Draftsmen and others who are anxious to improve their skill in freehand sketching and shading should find the material dealing with these phases of pictorial presentation to be of substantial aid.



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To tell whether the job can be done easier, better or cheaper . . . whether the total output of work will be more with a hydraulic torque converter (Lysholm-Smith type) or a hydraulic power take-off than with a friction clutch demands wide experience with both types of power links. That's why you are sure of unbiased recommendations when you submit your problems to Twin Disc engineers.

Twin Disc engineers have devoted over ten years to the research and development of hydraulics. Units covering a wide variety of applications of hydraulic torque converters and hydraulic power take-offs are now at work. In addition they have had over a quarter of a century's experience in adapting friction clutches to all types of power driven equipment.

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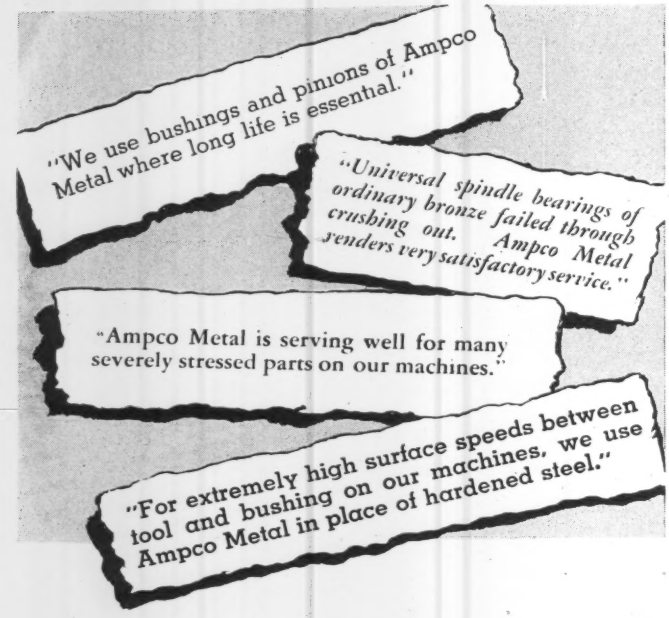
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AMPCO METAL show how to solve metal problems

Engineers in the machine tool industry have a very high opinion of Ampco Metal, based on years of experience with this aluminum bronze as standard material. They have tested it under actual operating conditions and proved to their satisfaction that it had hidden reservoirs of strength and service. It outperformed other bronzes, stood up under adverse conditions. Today over 90 machine tool builders use Ampco Metal as a matter of course—evidence of its general acceptance by the industry.

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DESIGN ABSTRACTS

Applying Plastics in Aircraft

IN COMPARISON with available metals plastics have definite advantages and at present, at least, just as definite deficiencies. Low density gives to the plastics structural superiority in many applications, particularly in monocoque and semimonocoque structures where strength against buckling is important. On the other hand there are some cases where the lower densities of plastics are a disadvantage—where limitation of size is necessary from the standpoint of aerodynamic efficiency and where design restrictions impose a limitation in overall dimensions.—*From a paper by John K. Northrop, president of Northrop Aircraft Inc., presented at the recent annual meeting of the Society of the Plastics Industry in Chicago.*

Chromium Plating Machine Parts

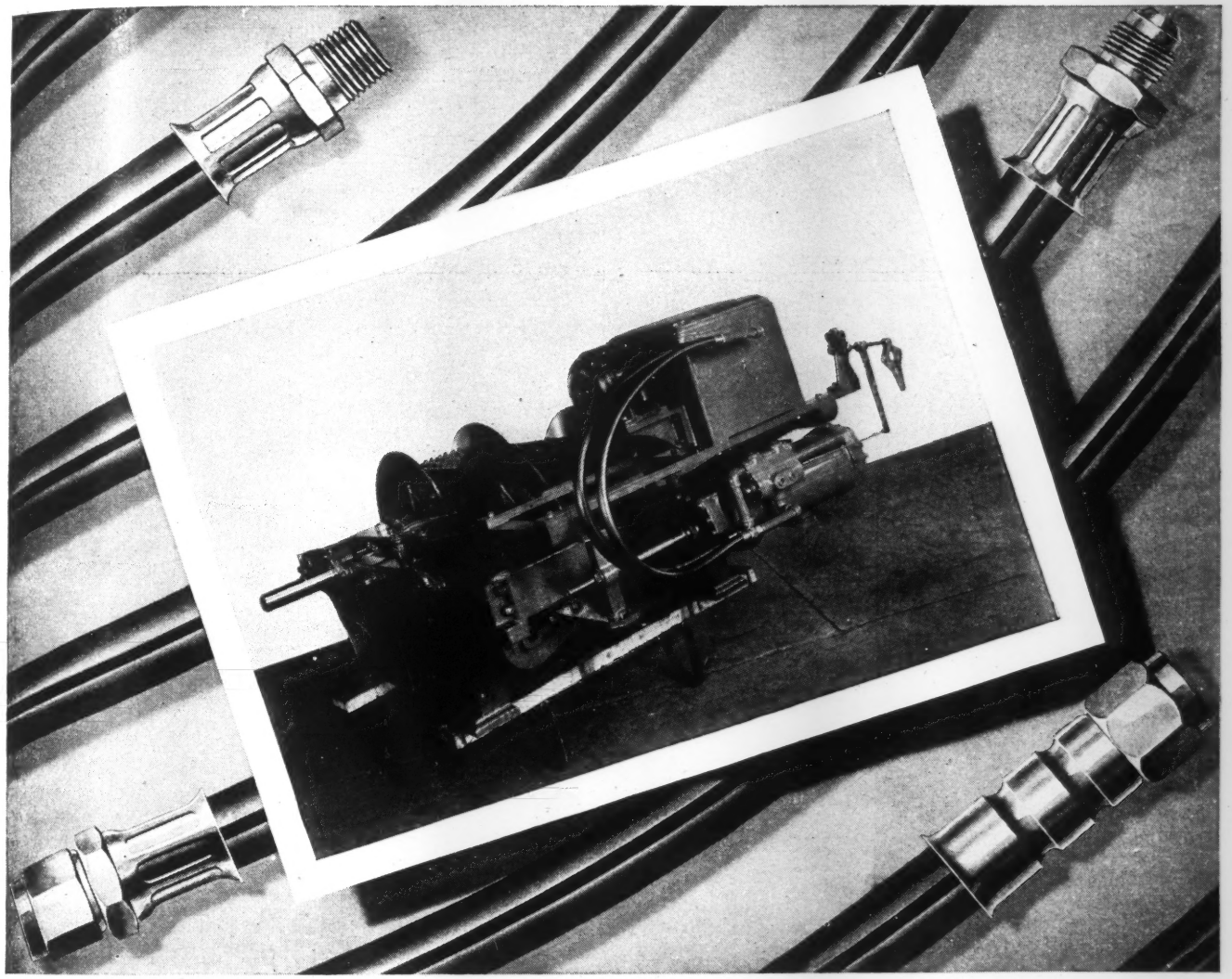
MOST applications of chromium plate on steel for engineering use are made primarily to obtain better abrasion resistance and to decrease wear on the plated article or part. Into this category fall most tools, cutters, gages and dies, as well as bearings, rods, plungers, and other machine parts. In the latter group the corrosion resistance of the chromium also contributes in important degree to the improved performance of the plated part, but the principal function of the plate is to withstand abrasion. Several of these wear-resistance applications of chromium plate are discussed below.

For most pump shafts, a chromium plate thickness of .0005 to .0015-inch (.001 to .003-inch on the diameter) is satisfactory, but for use under high-pressure packing heavier deposits should be applied, about .003-inch thick. On large shafts the work may be plated oversize (about .005-inch thickness) and ground back to size. The finish in all cases should be smooth, preferably buffed to a high luster.

Pump plungers and hydraulic rams are handled in much the same way as pump shafts. The plate thicknesses may run higher, .005 to .01-inch, and in extreme cases as high as .1-inch. All bearing surfaces of this type running against packing should be given a very smooth finish before use.

Many hydraulic parts are chromium plated, most of them similar to pump shafts or rams in plate requirements. Where they run through packing and a deposit of .0005 to .0015-inch is satisfactory, they may be plated to approximate size and buffed. Where they function inside a cylinder with close tolerance, they should be plated to oversize and ground with a residual plate of .001 to .003-inch in thickness.

Machine parts regularly chromium plated include cams,



Meet the longest-lasting flexible oil line REEVES *ever used...*

Even under the worst physical stress . . . even carrying the most corrosive organic solvents or oils, tough, flexible Resistoflex hose assemblies do not gum or erode, cause no clogging of fine hydraulic orifices . . . give year-in-year-out, trouble-free service. Reeves Pulley Co. knows this. On their Variable Speed Units Resistoflex lines have outlasted all predecessors, improved performance, lowered maintenance cost.

Resistoflex lines are *entirely* unaffected by fuels, oils and almost every organic solvent used in industry. They withstand severe and prolonged vibration, torsion, flexing and aging.

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Write for your copy of the Resistoflex Industrial Catalog. This booklet describes all types of Resistoflex industrial hose and hose assemblies.

RESISTOFLEX FEATURES:

NON-CLOGGING—Resistoflex hose does not gum, never clogs hydraulic or lubrication systems, diesel injector nozzles or other fine orifices.

PERMANENT, FULL FLOW—Chemically inert, glass-smooth inner surface provides permanent free flow—eliminates turbulence and skin friction.

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STRONGER—Resistoflex hose assemblies provide greater tensile strength than similar lines of equivalent size and construction.

HOSE AND HOSE ASSEMBLIES FOR HYDRAULIC OILS AND VACUUM, FUELS AND LUBRICANTS, ORGANIC SOLVENTS, PAINTS AND LACQUERS, THINNERS, REFRIGERANT, NATURAL AND MANUFACTURED GASES—LABORATORY TUBING—DIPPED AND MOLDED MECHANICAL GOODS—COATINGS, SOLUTIONS AND PROTECTIVE CLOTHING.

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Dare We Speak of Peace?

Yes—because it means so much to all of us individually. With it will come again those products of industry like the car, the radio and the refrigerator, which never were luxuries so much as necessities. And those who are thinking in post-war terms are asked to remember that Weatherhead will be prepared to help build these products again as well as the many strange new ones that are destined to emerge from this war.

Look Ahead with

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THE WEATHERHEAD CO., CLEVELAND, OHIO

Manufacturers of vital parts for the automotive, aviation, refrigeration and other key industries.

Plants: Cleveland, Columbia City, Ind., Los Angeles
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feed screws, spindles, lathe centers, crossheads, guides, and similar pieces. For the most part these take approximately .0005 to .003-inch in thickness, finished smooth to these dimensions by grinding or lapping to size after plating.

Steel-engraved printing surfaces require a deposit of only .0002 to .0005-inch for good service. Heavier deposits should generally be avoided to prevent loss of detail in finely etched areas.

In a number of wear-resistance applications outlined above, corrosion resistance also is an important factor, as on pump shafts, rods, and plungers, where resistance of the chromium to corrosion from the packing or material handled is a valuable characteristic. There are many applications where the opposite condition obtains: Where the part is chromium plated primarily for corrosion resistance—wear resistance, though possibly important, being a lesser consideration.

Plate thickness used for corrosion-resistance applications varies over wide limits, from .0002 to .0005-inch for bearing rollers operating in oil, to .01 to .015-inch or more on large rolls and operating equipment. Applications for corrosion resistance are numerous and varied and include calender rolls, table rolls, graining rolls, coating rolls, lehr rolls, drying rolls and drums, chemical handling and mixing equipment, tanks, food processing equipment, oil refinery equipment, and numerous other pieces of industrial equipment, besides many engine and other machine parts.—*From a paper by T. G. Coyle, technical director, United Chromium Inc., presented at the recent annual meeting of the American Society for Testing Materials, in Pittsburgh.*

Aluminum in Postwar Cars

ANY use of aluminum in postwar cars will have to be proved from both an economical and a practical standpoint.

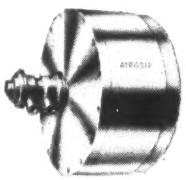
In the past, weight-saving programs involved making a few of the major parts light, resulting in a saving of a few hundred pounds, which made little difference in the car performance and was largely a matter of engineering department records.

The most logical place to start saving weight is on the heaviest units such as the powerplant assembly, where approximately 225 pounds can be saved in the weight of the average six-cylinder powerplant by use of aluminum cylinder block and crankcase, cylinder head, pistons, rods, intake manifold, transmission case and covers. The average car doors could be made approximately 30 pounds lighter per door, bumpers 40 pounds lighter, miscellaneous hardware 18 pounds lighter, rear deck 18 pounds lighter, hood assembly 34 pounds lighter, wheels 45 pounds lighter, and shock absorbers each 5 pounds lighter. A number of other miscellaneous parts would add up to approximately 500 pounds of aluminum parts, 200 pounds of which would be secondary alloy castings and competitive with cast iron, 15 pounds primary castings, 20 pounds forgings, 20 pounds die castings, and 270 pounds stampings.—*From a paper by Frank Jardine, Aluminum Company of America, presented at a recent meeting of the Detroit Section of the Society of Automotive Engineers.*

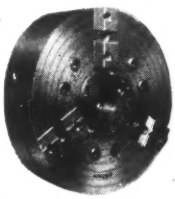
Output Will Go Up MORE THAN 25% WHEN "AIRGRIP" HOLDING DEVICES ARE INSTALLED

Here is a simple formula that will speed up your production more than 25% whether you employ men or women machine operators. ***Equip machines with "Airgrip" Revolving Air Cylinders and Air Operated Chucks.***

Old employees, relieved of time-wasting muscular effort, will make new production records. New employees, given minimum instruction, will produce at the full capacity of your machines—and, because "Airgrip" Holding Devices are so easy to operate, women will stay on the job a full turn without overtaxing their physical strength.



"Airgrip" Revolving Air Cylinders—positive and powerful.



"Airgrip" Air Operated Chucks—self-locking—save time and effort with safety.

Act today to get higher production and lower cost. "Airgrip" Holding Devices are available on short notice—they are easy to install—their cost is moderate—they pay big dividends from the first day of operation.

Anker-Holth also manufactures "Airgrip" stationary cylinders, and hydraulic cylinders. Our engineers are ready to help you on any problem where pneumatic or hydraulic adaptations can be made to machines.

Write for the new 'Airgrip" Bulletin!

This kind of "muscle grinding" penalizes you by more than 25% of potential output. Your machines will produce at full capacity as soon as you install "Airgrip" Holding Devices.

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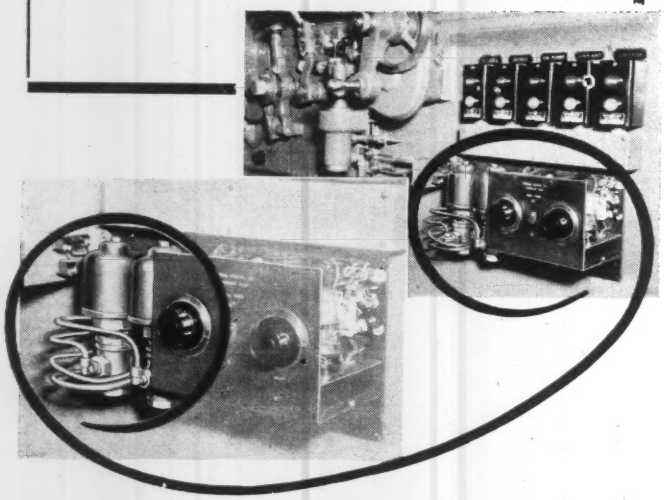
..... Assure Maximum Operating Efficiency of Equipment You Are Now Designing



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Adjustable Flow and By-Pass Valves

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Two-Way, Three-Way, and Four-Way Valves

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Special Valves

The list at the left will give you an idea of our line of ASCO Solenoid Valves. Some one type should take care of your problem perfectly.

Depending upon the type, sizes range from ⅛th inch up to 12 inches (pipe connections). Standard types are built for pressures up to 400 pounds and for temperatures up to 600°F. Specially lined valves for handling chemicals and explosion-proof solenoids are available.

The above describes briefly the ASCO Line of Solenoid Valves. Circular 148 will give more details and Catalog 149 will give complete technical data. Back of these valves are 55 years of experience gained by specializing in this work. Why not bring your control problem to us?

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We also manufacture a comp'ete line of Electrically Operated, Magnetically Held and Mechanically Held Transfer Switches and Remote Control Switches; also Relays, Contactors and Panels.

Automatic Switch Co.

49 East 11th St., New York City

TELL US WHAT YOU WISH TO ACCOMPLISH

Synthetic Tubing

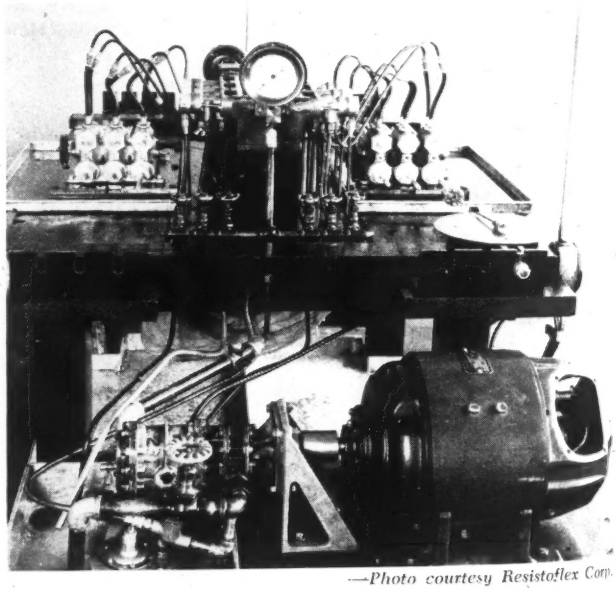
(*Continued from Page* 128)

EFFECT OF OILS AND AROMATIC FUELS: There are numerous machine applications where flexible conduit for oils and aromatic fuel is required. Two types of semi-rigid plastic tubing which show promise for this purpose are polyvinyl alcohol and polyvinylidene chloride. An application of the latter to an automobile engine is illustrated in *Fig.* 8.

Mentioned frequently in connection with the handling of turbine oils and gasoline-aromatic blends are various synthetic rubber vulcanizates which are identified as follows:

Butaprenes—Modified butadiene-acrylonitrile copolymer
Chemigums—Modified diolefin copolymer
Hycar—Modified butadiene copolymer
Perbunan—Butadiene-acrylo nitrile copolymer
Thiokol—Organic polysulphide
Neoprene—Chloroprene polymer

Recent tests by U. S. Navy Yards° disclose the superior performance of Thiokol F, Hycar OT and Chemigum X in gasoline-aromatic blends of fuel. On the other hand, in turbine oil most of the synthetic vulcanizates performed well at 82 degrees Fahr. and at 190 degrees Fahr., suffering only minor changes in strength and volume. It is



—*Photo courtesy Resistoflex Corp.*

Fig. 7—Severe mechanical strains due to flexing of these lines on a hydraulic test set-up are successfully met by polyvinyl alcohol tubing

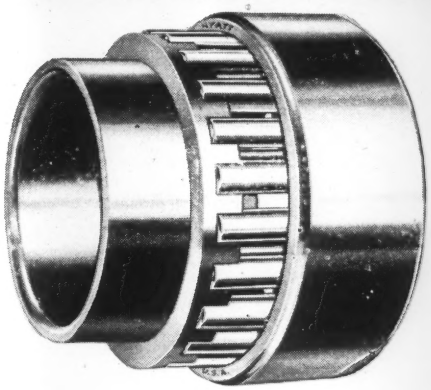
a noteworthy fact that in all of the tests these materials are far superior to natural rubber, which cannot begin to compete with some of the synthetics in general resistance to oils and gasoline.

TEMPERATURE LIMITATIONS: In examining the merits of installing plastic tubing the question of temperature frequently arises. Naturally the softening or heat distortion point of the plastic material should give a clue as to the correct range. Most of the thermoplastics are limited to temperatures below 200 degrees Fahr., though this is

°*Rubber Age*, July, 1943, Page 335.

This is THE BIG INCH of Pipelines—
Greatest Capacity **of any pipeline ever built**

—and this is the "BIG INCH"



OF ROLLER BEARINGS

These "Inch Series" Hyatts...like their famous pipeline namesake...have tremendous capacity... measured in tons and hundreds of tons.

And...as a further advantage...they are made in fractional size bores, for shafts from 4" diameter upwards.

Originally designed for the massive, heavily loaded, relatively slow moving oil well machinery, the use of this type of Hyatt Bearings (70,000 series) quickly spread.

Today they are serving and saving in mining equipment, industrial locomotives, power presses, pillow blocks, cranes and steel mill cars...as well as in numerous types of fighting equipment.

Keeping pace with the demands of industrial designers for the latest and best in anti-friction bearings has been Hyatt's job for fifty-one years.

The "Big Inch" is just one of the several types of Hyatt Bearings now being made. Each of them is designed for specific needs and purposes.

Call on our engineers for information about their profitable application to your products.

HYATT BEARINGS

Division of GENERAL MOTORS

HYATT BEARINGS DIVISION · GENERAL MOTORS CORPORATION · HARRISON, N. J.

Hollow tumbling barrel axles, or journals, made from this tubing have the strength to stand up under a constant combination of weight and movement.

The *uniform wall thickness* of this tubing means more strength—and a greater factor of safety. Carpenter Welded Stainless Tubing often permits the use of *lighter gauges* without sacrificing strength. Then too, the high strength-weight ratio of the Stainless Steel from which this tubing is made helps to strengthen parts, save weight and space.

Easier, faster fabricating also results from using this tubing. Lighter gauges mean faster bending, forming, welding, etc. And the *uniform structure* of Carpenter Welded Stainless Tubing can save you many production worries. Even the V-shaped weld is chemically and mechanically analogous to the parent metal.

Since the days of Carpenter's development of this type of tubing, we have been sharing our diversified experience with others. So drop us a line for help with your design-engineering problems.

USE THIS FOLDER . . .

to help you select the type of Welded Stainless Tubing for your needs. It contains data on physical properties, corrosion resistance qualities; sizes and shapes available. A note on your company letterhead will start this useful information on its way to you.

THE CARPENTER STEEL COMPANY

Welded Alloy Tube Division . . . Kenilworth, N. J.

Carpenter

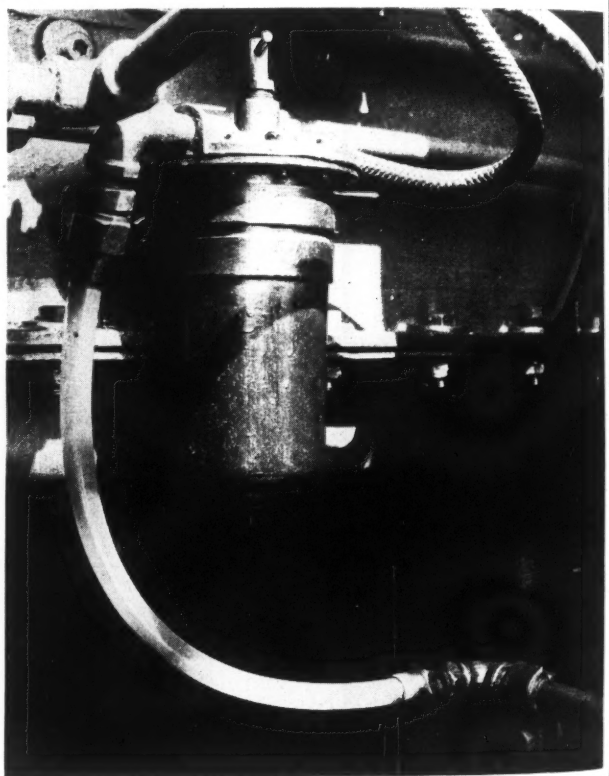
WELDED

STAINLESS TUBING

determined also to some extent by the working pressure, which for some plastic tubing is quite high. For example, polyvinylidene chloride tubing has been used in some applications at temperatures of 170 to 180 degrees Fahr. On the other hand, the extruded cellulose plastics are best employed at lower temperatures.

None of the semirigid plastic tubings can really be considered as rubber-like or very flexible at low temperatures (—40 degrees Fahr. and lower). Like their rubber equivalents they stiffen and become more brittle at such temperatures. On the other hand, with the more rigid thermosetting phenolic tubing a greater latitude of temperature may safely be employed.

ELECTRICAL INSULATION: A small but nevertheless highly significant application of extruded, rubber-like plastic tubing (such as plasticized polyvinyl chloride or polyvinyl copolymer) is as electrical insulation. Tubes



—*Photo courtesy Dow Chemical Co.*

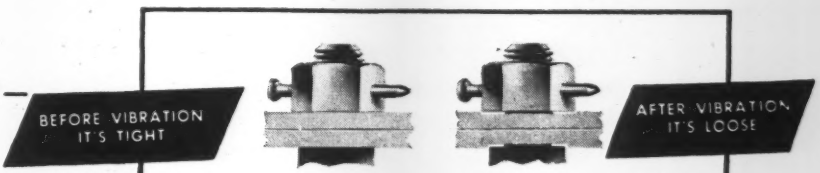
Fig. 8—Resistance of polyvinylidene chloride tubing to the action of oils and fuels enables it to be used on internal combustion engines

of such material may be slipped over other forms of insulation to protect them from gasoline, oil or other deleterious agents, or they may comprise the entire insulation of an electrical circuit. Available in many colors (Irvolite tubing, for example) they are a boon in electrical installations. They have an important advantage over rubber in permanent flexibility and resistance to swelling by grease or oils.

Plastic tubing of various types today is fulfilling numerous applications to mechanical equipment. While there are certain limitations, the designer should make himself well acquainted with their basic characteristics because there are many problems best served by these materials.

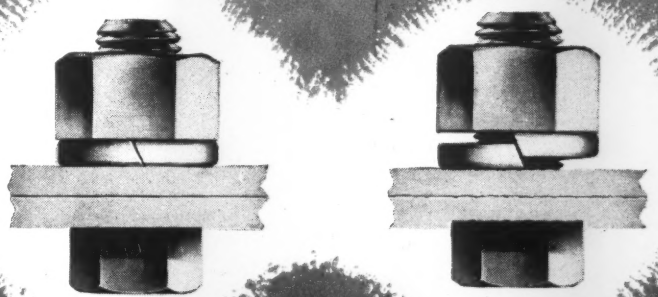
YOU CAN'T GO ALL THE WAY ON HALF-WAY MEASURES

Here's a halfway job — with a fixed nut alone.



— and the nut never moved — it couldn't move, we spiked it to prove our point.

HERE'S A WHOLE WAY JOB, ANY NUT PLUS A KANTLINK SPRING WASHER



BEFORE VIBRATION—IT'S TIGHT

AFTER VIBRATION—IT'S STILL TIGHT

— still the nut never moved,—it could not. The spring washer held it tight by expanding as other parts wore, for all parts do wear under vibration and stress.

Only a strong helical **spring** washer can expand and compensate for inevitable wear, bolt stretch, abrasion, lapping, etc. Kantlinks prevent dangerous loosening of all bolted assemblies.

There is **no substitute** as economical. No fixed nut nor any short range multi-toothed washer can possibly equal the great holding power of a **long range live spring**—a big helical spring such as Kantlink.

Let us send you samples—send details of your application. Test and compare them on the same job with **any** type of nut, or with **any other type** of washer. Kantlinks can't lose a real test. Try them for efficiency, economy and real safety.

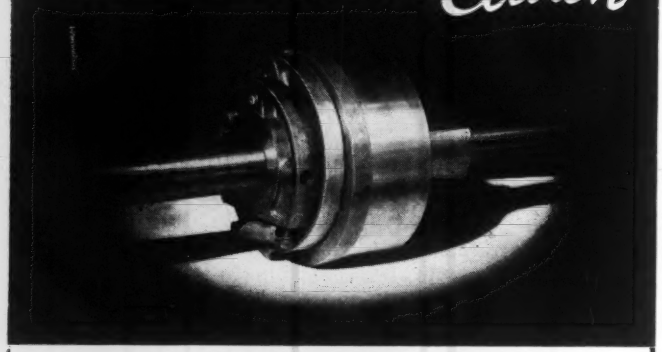
Write today for descriptive folder.

KANTLINK TRADE MARK

the long-range Spring Washer

THE NATIONAL LOCK WASHER COMPANY
NEWARK, N. J., U. S. A.

★ ★ ★ THE HILLIARD ★ ★ ★
SINGLE REVOLUTION *Clutch*



Wherever extremely accurate control of intermittent machine operation is essential the Hilliard Single Revolution Clutch is unequalled. Its accuracy has won for it the acceptance of Industry for cutting, punching and packaging operations.

★ WRITE TO-DAY!
For information that will help you to adapt this clutch to your needs.

THE HILLIARD CORPORATION
103 W. Fourth St.
ELMIRA, N. Y.

★ OVER-RUNNING ★ SLIP ... CENTRIFUGAL ★ FRICTION

HIGH FLUSHING CAPACITY
with
GUSHER
COOLANT PUMPS

Model 11020-A

And yet, you can cut down the flow to a mere dribble without building pressure.

Gusher Coolant Pumps are being used by leaders in the industry for grinding, honing, cutting, milling, tapping and threading.

Learn the exclusive advantages of Gusher Coolant Pumps. Sizes and types from 1/10 to 2 h.p.

Write for data and specifications

THE RUTHMAN MACHINERY CO.
1811 READING ROAD CINCINNATI, OHIO
LARGEST EXCLUSIVE BUILDERS OF COOLANT PUMPS

BUSINESS AND SALES BRIEFS

TO SUPPLEMENT the activities of Ralph E. Dorland, who has been in charge of the New York office for several years, officials of Dow Chemical Co. have appointed Clayton S. Shoemaker as eastern sales manager and Frederick A. Koch as assistant to Mr. Shoemaker. Headquarters will be established at 30 Rockefeller Plaza, New York City. Appointed by Mr. Shoemaker, Alexander Leith Jr. is now manager of the Philadelphia office and Alfred A. Lawrence, manager of the Boston office.

♦

Formerly metallurgical service representative for the Timken Roller Bearing Co. in Cleveland and Detroit, S. R. Kallenbaugh has been appointed west coast district manager of the Steel and Tube Division of the company, with offices at 1526 South Olive street, Los Angeles, Calif.

♦

McKenna Metals Co. of Latrobe, Pa., has been succeeded by Kennametal Inc., a corporation of Pennsylvania. Personnel, management, products and policies remain the same.

♦

Thomas R. Coffey has been appointed manager of sales for the Wisconsin-Minnesota district of Globe Steel Tubes Co. of Milwaukee.

♦

Serving formerly as salesman, Ray E. Palmer has been named manager of the Boston office of Aluminum Co. of America to succeed Gordon W. Cameron.

♦

Powder Metallurgy Inc., Long Island City, N. Y. has been absorbed by General Bronze Corp. which has five other plants operating in the same area.

♦

A new technical sales staff of six metals specialists is announced by Jessop Steel Co. Washington, Pa. Its members are: John R. Harbaugh for special applications of alloy and die steels, H. E. Doughty, specializing in high-speed tool steels, R. P. J. McCarty and W. E. Wilson for stainless steel applications, John Walker on composite steels and E. H. Dau, special representative on sheet and plate. These men will be concerned with inquiries on the availability and adaptability of steels in their particular fields.

♦

Succeeding the late Emeric R. Leonard, Robert P. Willey has been appointed sales manager, Washington office, Bethlehem Steel Co., Bethlehem, Pa.

♦

Formerly vice president of Phoenix Iron Co., Phoenixville, Pa., Malcolm Farmer has been elected vice president and general manager of Plastic Manufacturers Inc., Stamford, Conn.

♦

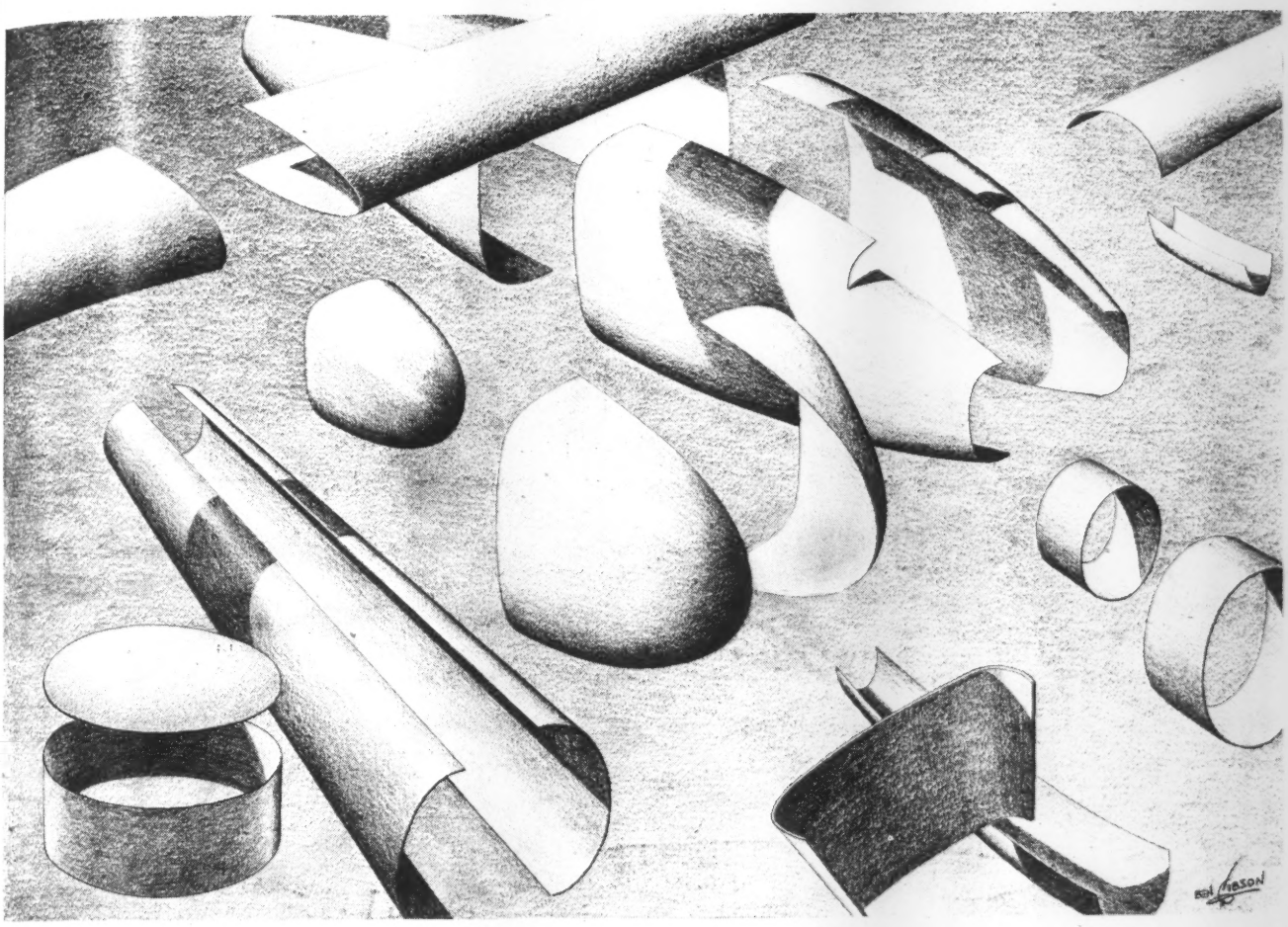
Established in 1940 by Ralph Penn, treasurer, Penn Electric Switch Co.'s special research department has been transferred from St. Louis to the home plant in Goshen, Ind.

♦

Arnold Tietig III has been elected president of the Metal Specialty Co., Este avenue, Cincinnati.

♦

According to a recent announcement, Elmer Gammeter has recently resigned as manager, Stainless Steel bureau, Chi-



PLYMOLD* Offers Unusual Advantages in Planning

THE SHAPE OF THINGS TO COME

• Everywhere future-minded engineers are analyzing America's wartime achievements with the view of further advancements in both construction and operating efficiencies and economies.

One of these developments is Haskelite *Plymold*—the newest precision material.

Haskelite *Plymold* is plywood in a new structural form which meets strict engineering requirements and lends itself to mass production. By means of the Plymold process, wood veneers are laminated over simple dies . . . in small sizes or in sections as large as a bomber fuselage. Large sections may be molded in compound curvatures. To meet stress requirements, thickness variations can be provided in any section.

Now widely used in the mass production of advanced training planes and gliders and sturdy PT boats, Haskelite *Plymold* has convincingly demonstrated its versatility and dependability.

In your planning for new and improved products shaped to meet ever changing war and peace time needs, you will do well to look searchingly into the possibilities of Haskelite *Plymold.*

*(T. M. Reg. U. S. Pat. Off.)

HASKELITE MANUFACTURING CORPORATION
GRAND RAPIDS 2, MICHIGAN
OFFICES: CHICAGO • DETROIT • NEW YORK

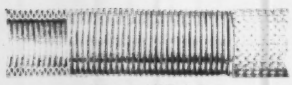
HASKELITE
PLYMOLD MARINE PLYWOOD AIRCRAFT PLYWOOD
Plymetl Phemaloid

REX-WELD
Helps Guard
HIS LIFE

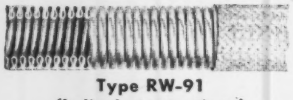
REX-WELD Flexible Metal Hose has met the critical test that demands only the best materials for our combat planes. More and more bombers, fighters and interceptor-pursuit ships are being Rex-Weld equipped.

REX-WELD'S war service is not confined to the planes themselves. In the steel mills and munition factories, on the production and assembly lines, everywhere that war-worthy flexible connections are needed, REX-WELD is rendering vital service.

There are specific reasons for this. REX-WELD is a specially constructed flexible metal tubing. It is fabricated from strip metal by a precision autogenous welding process that produces uniform, stronger wall structure plus extreme flexibility. REX-WELD stands up under high pressures, high and low temperatures, extreme contraction and expansion. It is seep-proof to gas, water, oil, air and searching fluids.



Type RW-81
(annular corrugations)



Type RW-91
(helical corrugations)

Available in continuous lengths to 50 ft. Both Steel and Bronze. 3/16" I. D. to 4" I. D. inc. Pressures to 14,500 p. s. i. Temperatures to 1000° F.

Write for Engineering Recommendations

CHICAGO METAL HOSE CORPORATION

General Offices: MAYWOOD, ILLINOIS

Factories: Maywood and Elgin, Illinois

cago District Metallurgical division, Carnegie Illinois Steel Corp., to become chief metallurgist, Globe Steel Tubes Co., Milwaukee. Mr. Gammeter terminates 15 years' active service in metallurgical work in the Chicago area.

♦

Establishment of a branch office in Cleveland has been announced by Dow Chemical Co. D. T. Wellman, formerly of the sales department in Midland, Mich., will head the Cleveland organization, assisted by T. H. Caldwell Jr. of the magnesium production division. Located on the 23rd Floor of the Terminal Tower, the new office will serve Cleveland, Pittsburgh, Buffalo, Toledo, Dayton, Cincinnati, Columbus, Akron and Detroit.

♦

After seven years as general sales manager, K. R. Beardslee has been named vice president in charge of sales for Carboloy Co., Detroit. Associated with the company for thirteen years, Mr. Beardslee first served in the Newark branch office and later as district manager in the Pittsburgh office.

♦

Succeeding Everett Chapman, who resigned to establish his own business as a consulting engineer, C. L. Huston Jr. has been named president of Lukenweld Inc., a subsidiary of Lukens Steel Co. of Coatesville, Pa. A 1928 B.S. graduate of Princeton, Mr. Huston, after a year of special studies in metallurgy at M.I.T. served ten years in the employ of the American Rolling Mill Co. of Middletown, Ohio.

They Say . . . .

"There is every reason to believe that television, which is already as far advanced as radio broadcasting was in 1927, will become one of the great industries of the postwar period. In terms of employment, production and sales, it should far surpass the records previously made in the phenomenal growth of the radio industry."—David Grimes, vice president in charge of engineering, Philco Corp.

♦

"Postwar automobiles will be small, lightweight editions fueled by high-octane, heavily-taxed gasolines now available only for military aircraft and motorized equipment. Postwar manufacture of 100-plus octane gasolines will force engineers to design diesel engines which will get the utmost out of low-octane fuels for railroad, marine, long-distance and overseas air cargo, and construction service."—Dr. C. M. Larson, chief consulting engineer, Sinclair Refining Co.

♦

"Any ton of copper saved by skillful engineering does not mean merely that a few hundred dollars are saved but that this copper can be used to manufacture some 80,000 machine gun cartridge cases. Even if only 1 per cent of these rounds of ammunition reach their goal, there will be 800 fewer enemies facing us, and the end of the war will be that much nearer."—L. A. Umansky, assistant manager, industrial engineering department, General Electric Co.

♦

"President Roosevelt's expressed wish that the number of vessels to be turned over to Great Britain by the War Shipping Administration be increased to twenty is easily possible of accomplishment . . . advances in welding technique now being used and their further application will increase productivity of welding by 25 to 50 per cent. Translated into terms of number of ships built, this would means a proportionate increase in the number of vessels which might be turned over to Great Britain."—J. F. Lincoln, president, The Lincoln Electric Co.

Reanite

UNITES METAL TO METAL, OR RUBBER, PLASTICS, LEATHER AND WOOD TO METAL, OR TO EACH OTHER, WITH A BOND, IN MANY INSTANCES, STRONGER THAN THE MATERIALS THEMSELVES

The World of Tomorrow will be welded with a paint brush

EQUAL or superior to riveting or spot welding for many purposes, the Reanite Bonding Process* not only accomplishes substantial savings in production man hours, but through its unique ability to bond entirely unrelated materials permits design engineers to take full advantage of the specific properties of each.

The normal bond between metals exceeds 1000 lbs. psi on a pull test, and for some metals runs as high as 3000 lbs. On bonds formed between rubber and metal, or between wood and metal, wood and rubber, or between wood and wood, the materials themselves will give way before the bond.

Reanite is suitable for almost all metal surfaces — iron, steel, stainless steel, magnesium, aluminum, aluminum alloys, copper and bronze. It is particularly effective in bonding light metals such as magnesium and aluminum.

The Reanite Bonding Process is simple. Reanite adhesive is applied by brush or spray gun to the surfaces to be joined. Mild heat and pressure is applied.

The Reanite bond is insoluble in water, is *non-corrosive to metals,* and is effective through a temperature ranging from —40 °F. to as high as 300 °F.

Is Reanite available now? Yes. Reanite is formulated through cyclic modifications of materials high on the critical list, but for essential end-uses Reanite is available for immediate shipment.

**The Reanite Process is fully protected by United States and foreign patents, granted or pending.*

U. S. STONEWARE

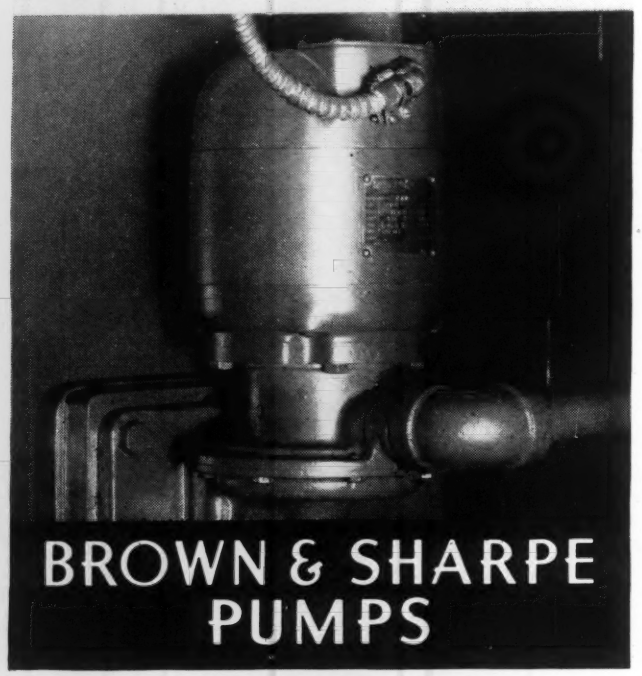
AKRON, OHIO

REANITE — ANOTHER U. S. STONEWARE PRODUCT — PERFECTED UNDER THE IMPETUS OF WAR — DESIGNED FOR THE NEEDS OF PEACE

There's No Intake Piping needed with No. 240

Brown & Sharpe Motor Driven Centrifugal Pumps No. 240 have intakes incorporated in flange mountings. Installations are neat and simple. Send for complete pump catalog. Brown & Sharpe Mfg. Co., Providence, R. I., U. S. A.

B·S



BROWN & SHARPE PUMPS

HYDRON

HYDRON Metal Bellows

Metallic Bellows

We manufacture bellows and bellows assemblies ready for installation in steam traps, relief valves, temperature regulators, pressure regulators, air valves, and other automatic temperature and pressure controls. Complete engineering service.

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BOSTON, MASS.

DETROIT
1847 W. Bethune Ave.

Fatigue Failure

(*Concluded from Page* 110)

per day until failure occurred. Each day's run involved an addition of about 2.5 million cycles. Furthermore, after it was found that 10 million cycles increased the endurance limit 6 per cent, a number of specimens were tested at 26,000 pounds per square inch for 10 million cycles, then a second run of 10 million cycles at 6 per cent overstress, and finally various "coaxing" increments were progressively added.

These tests show that after the first two runs coaxing will increase the endurance limit further. It is true that usually the runs used in coaxing were for only 2.5 million cycles, so that the actual endurance limit was not being obtained at these higher stresses. However, it appears that when the stress used in coaxing is not too large the final stress at failure is not so greatly different no matter what coaxing method is used. This result would lead one to conclude that there is an upper limit beyond which strengthening in fatigue cannot be carried further. The understressing tests on cast iron reported by the author in 1930 indicated that the optimum strengthening was obtained by using a stress just under the endurance limit.

While the effect of understressing and subsequent coaxing is marked in the increase obtained for the endurance limit, and in the increase of the stress which can be applied for an appreciable number of cycles, the effect is even more marked when examined from the standpoint of the greater life or number of cycles that the material can endure at the higher stresses. *Fig.* 4 shows this plainly. The smooth curve represents the *S-N* diagram obtained on standard smooth specimens of annealed ingot iron. The stepped curve shows the operations that were performed in the case of one of these tests.

Endurance Life Greatly Increased

The next to the last run was for a full 10 million cycles at a unit stress of 33,600 pounds per square inch, or 28 per cent above the original endurance limit. Normal life of a specimen at this unit stress was about 85,000 cycles. Therefore, a run of 10 million cycles represents an increased life that is 118 times the normal life, or an increase of 11,700 per cent. This, however, does not represent the full increase in the endurance life at this unit stress. Since the specimen ran another 7 million cycles at a higher stress, it is probable that it would have run at least another 10 million cycles at 33,600 pounds per square inch. This would be 235 times the normal life, or an increased life of 23,400 per cent.

Even at the highest stress applied, which was 34,100 pounds per square inch, the specimen ran over 7 million cycles before failure. Normal life at this unit stress was about 65,000 cycles. The run of 7 million cycles represents an increase in life of 108 times, or 10,700 per cent.

TABLE I shows that understressing may increase the endurance limit of annealed ingot iron by 23 per cent. *Fig.* 4 shows that the effect of understressing plus subsequent coaxing has a much more marked effect on endurance life than on endurance limit, and that endurance life may be increased by relatively enormous percentages.

WAGNER PRODUCTS SPEED VICTORY!

THOROUGH INSULATION

IS ONLY ONE OF THE MANY REASONS WHY

Wagner MOTORS

Stay on the job!

All Wagner motors are built to exacting specifications, and embody characteristics and features that give them long life, dependability and added protection against failure. Wagner engineers will not compromise on "good enough" insulation — all windings must be thoroughly insulated. This is only one of the many reasons why Wagner motors stay on the job.

The illustrations on this page show typical polyphase stator windings. The stator cores of all Wagner polyphase motors are well insulated, using special slot cells formed from tough fibrous material, cuffed on each end for extra strength. The coils and free ends are shaped to fit snugly into the slots so that there is no possibility of vibration and at the same time the windings are easily put into place. Heavy separators are used between the coils in the slot and inverted U-shaped cells fit over the tops of the coils under the slot wedges. The free ends of the windings are completely taped well into the slot cells, and heavy sheets of black varnished muslin are slipped between the coils of the various phases to insulate them from each other.

After the windings are in place, the stator is baked to remove all moisture, and while still hot it is immersed in a heavy insulating varnish. When the heated stator core is immersed in the much cooler varnish a suction is created which produces complete impregnation of the windings. The stator is immersed long enough so that the insulating varnish impregnates the innermost portions of the coils. The stator is then baked again until this coating is completely dried. It is then given another dipping and baking to insure complete impregnation and to provide an added moisture-resisting coating. Finally, the stator is sprayed with air-drying varnish, which not only provides further resistance to oil and moisture, but also gives the coils a glossy surface.

WRITE FOR COMPLETE INFORMATION

Complete information on Wagner motors will be sent upon request. Wagner is a nation-wide organization with branches in twenty-nine principal cities. Each branch office is manned by trained field engineers ready to help you solve your motor-drive problems.

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ELECTRICAL AND AUTOMOTIVE PRODUCTS

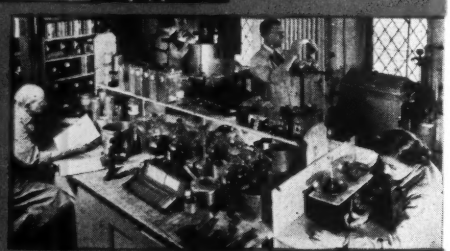
M43-13

HAVE YOU A *Problem Child* IN YOUR FINISHING DEPARTMENT ?

BILLY WRINKLE SAYS: LET'S LICK IT WITH LABORATORY RESEARCH AND WRINKLE FINISH

The new spraying, baking and cooking room of the New Wrinkle laboratory.

A section of the laboratory devoted to general testing. Equipment includes a Paint Mill and Salt-Spray Cabinet.



Another section of the enlarged laboratory where testing is conducted. In the background, to the right, is an accelerated weathering machine.

A recent expansion program has doubled the laboratory research facilities of NEW WRINKLE, and before many months pass they will have been trebled! This makes it possible to extend our service to a greater number of manufacturers with finishing problems. Tell us what they are. There is no question but what we can help you materially.

Write for a new copy of NEW WRINKLES IN FINISHING. It shows what can be done to meet finishing conditions as they exist today.

NEW WRINKLE INC.

314 W. FIRST ST. · · · DAYTON, OHIO

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NEW MACHINES—

And the Companies Behind Them

(*For illustrations of other outstanding machinery, see Pages 130, 131*)

Engineering Department

°Blueprinting machine, Paragon-Revolute Corp., Rochester, N. Y.

Industrial

Portable oil filter, Hilliard Corp., Elmira, N. Y.
Lubricating oil reclaimer, Youngstown Miller Co., Sandusky, O.
Aero heat exchanger, Niagara Blower Co., New York.
Oil-treating, filtering and reconditioning unit, Sparkler Mfg. Co., Mundelein, Ill.
Generator, Kato Engineering Co., Mankato, Minn.
Coolant cooler, Frostrode Products, Detroit 3.
Spray degreasing machine, The De Vilbiss Co., Toledo, O.
°Industrial washing machine, Industrial Washing Machine Corp., New Brunswick, N. J.

Laboratory

Laboratory furnaces, Lindberg Engineering Co., Chicago 12.
Improved rockwell hardness tester, Clark Instrument Inc., Dearborn, Mich.
Machine for identifying quality of steel, American Tubular Elevator Co., Pittsburgh.

Materials Handling

High lift truck, The Baker-Raulang Co., Cleveland.
Hydraulic elevating table, Lyon-Raymond Corp., Greene, N. Y.

Metalworking

°Connecting rod boring machine, Century Engineering Co., Los Angeles
°Automatic machine for milling binder bar slots in aircraft cylinder heads, Snyder Tool & Engineering Co., Detroit.
°Cable stretcher, The Parker Appliance Co., Cleveland.
°Machine for centering round bars, Whitcomb Mfg. Co., Troy, O.
°Two-spindle deep hole cylinder boring machine, W. F. & John Barnes Co., Rockford, Ill.
°Grinder with pantograph and microscope, The Sheffield Corp., Dayton, O.
Carbide tool grinder, Thomas Prosser & Son, New York.
Heavy-duty turret lathes, International Machine Tool Corp., Libby Division, Indianapolis.
Drilling, boring and milling machine, Snyder Tool & Engineering Co., Detroit.
Quick-change gear lathe, Logan Engineering Co., Chicago.
Hydraulic bender, Beatty Machine & Mfg. Co., Hammond, Ind.
2000-ton mechanical trimming press, E. W. Bliss Co., Brooklyn.
Vertical, universal milling and slotting machine, Hack Machine Co., Desplaines, Ill.
Self-contained piercing press, Dayton Rogers Mfg. Co., Minneapolis.
Profile miller for odd-shaped parts, E. A. Thompson Mfg. Co., Ferndale, Mich.
Spinning lathe, Ferracute Machine Co., Gridgeton, N. J.
Metal-cutting saw for various shaped pieces, Kalamazoo Tank & Silo Co., Machine Tool Div., Kalamazoo, Mich.
Portable boring and facing machine, General Engineering & Mfg. Co., St. Louis.
Chip breaker-grinder, Delta Mfg. Co., Milwaukee.
Heavy-duty die sinking machine, Fitchburg Engineering Corp., Fitchburg, Mass.
High-speed precision bench grinder, Sanford Mfg. Co., Irvington, N. J.
Single-spindle tapping machine, L. J. Kaufman Mfg. Co., Manitowoc, Wis.
Bench model automatic rivet bucker, Aero Tool Co., Burbank, Calif.
Metal-cutting band-sawing machine with gravity feed, Universal Vise & Tool Co., Parma, Mich.
Improved 5-station turret lathe, Automatic Machine & Tool Co., Auburndale, Mass.
Hydraulic precision thread-rolling machine, National Electric Welding Machine Co., Bay City, Mich.

Milling

Grading machine, Hart-Carter Co., Minneapolis.

Office

Communication system with new annunciator selector, Executone Inc., New York.

Railroad

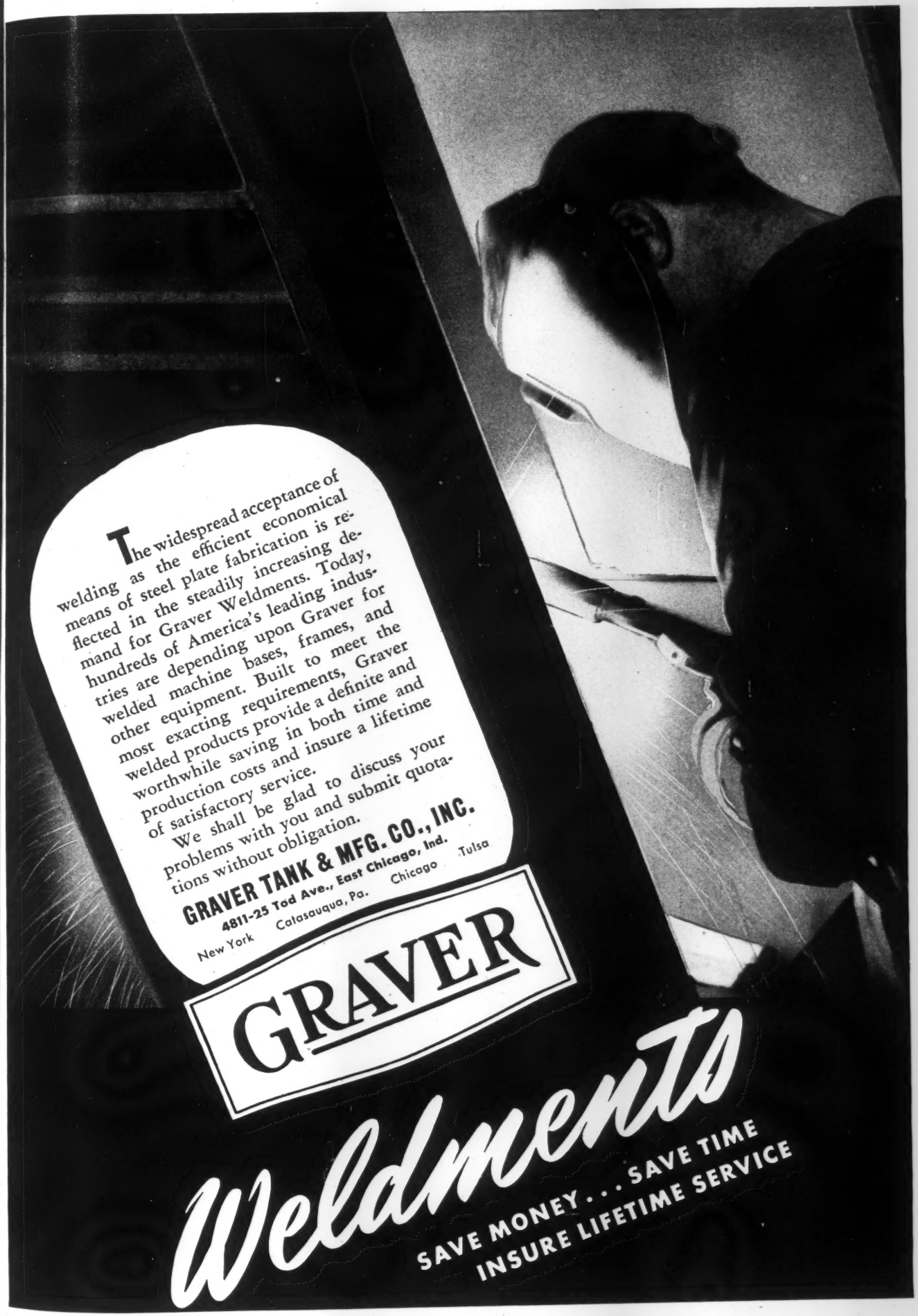
Locomotive, American Locomotive Co., New York.

Testing

Hardness tester, Clark Instrument Inc., Dearborn, Mich.
Hook checker for thread milling cutters, Detroit Tap & Tool Co., Detroit 11.

° Illustrated in pictorial spread, Pages 130, 131

(*Concluded on Page 200*)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